POWER

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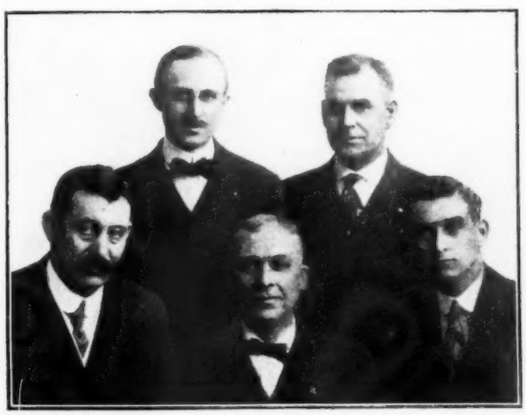
Thirty-Fourth Convention N. A. S. E.

Minneapolis, Minn., September 11 to 16, 1916

May this annual meeting be bigger and better than ever before



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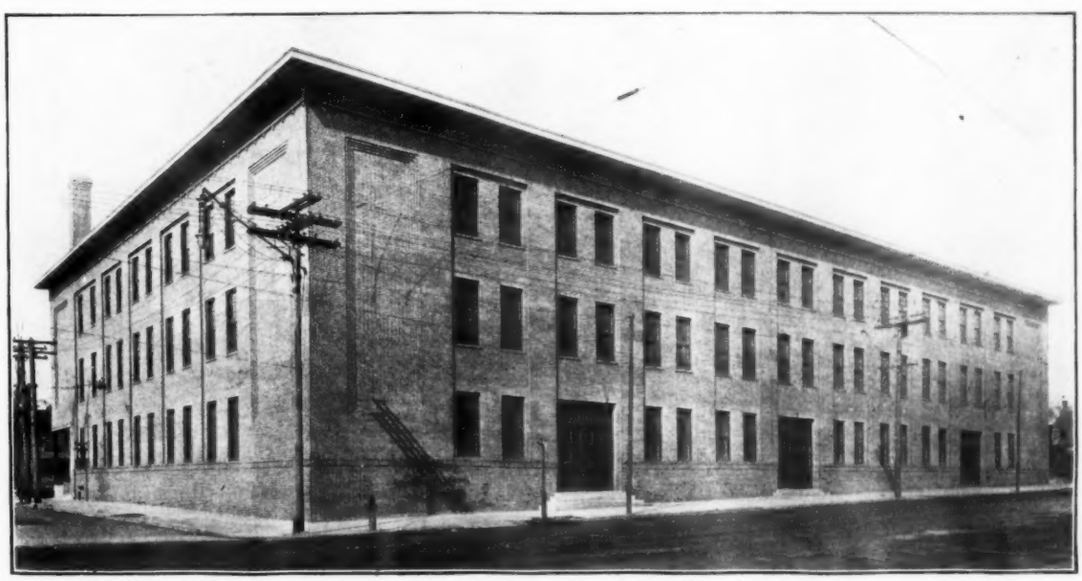


PENCE AUTOMOBILE WAREHOUSE, WHERE EXHIBITS WILL BE DISPLAYED

Twin-City Power Plants

By Thomas Wilson

SYNOPSIS—Features of a number of the leading plants in the Twin Cities. Typical installations have been taken and each plant has some point of interest well worth the time required to look it over. All will be open for inspection.

The Twin Cities, Minneapolis and St. Paul, contain a number of low-head water-power and steam plants that should interest engineer delegates or visitors to the N. A. S. E. national convention. The features of a number of these plants are enumerated in the following outline. With one exception all are within the limits of either city, but in passing from one center to the other the midway section should not be neglected, as here there are a number of modern manufacturing plants well worth the time required to look them over.

Commercial lighting and power are supplied in the two cities by the Northern States Power Co., which is under Byllesby control. Within a radius of 75 mi. a number of water-power plants tied into a system common to all carry the load up to their capacity limits, and the balance is cared for by the steam plants belonging to the company.

For Minneapolis, Riverside Station is the steam stand-by plant. It has been remodeled recently and now contains two 6,000- and one 15,000-kw. horizontal turbo-generators, all served by individual surface condensers. For the smaller units the condenser auxiliaries are steam-driven, while those of the larger turbine are driven by motor, with the exception of the dry-vacuum pump, which is of the two-stage one-cylinder type. An air washer cools and cleans the air for the large generator. Three-phase 60-cycle current is generated at 2,300 and 13,200 volts.

Steam is supplied by twelve 300-hp. water-tube boilers at 200 lb. pressure and 125 deg. of superheat. The stokers are of the underfeed type with seven retorts per boiler, the blast fans being driven by geared turbines.

Steam is kept up at all times, so that the station may take the load instantly. During certain hours of the day the generators are motored, that is, run as synchronous motors for system voltage regulation. They are operated in the same way during threatening weather, so that if lightning or other troubles should interrupt the service, the load may be instantly taken by the turbines. At such times a small amount of steam is fed around the throttle through a ¼-in. pipe into the turbine to keep the blading cool. This may sound paradoxical, but experience has shown that the steam prevents overheating and eliminates operating difficulties.

The company has a similar plant at St. Paul containing two 1,000-, one 2,000- and one 4,000-kw. hori-

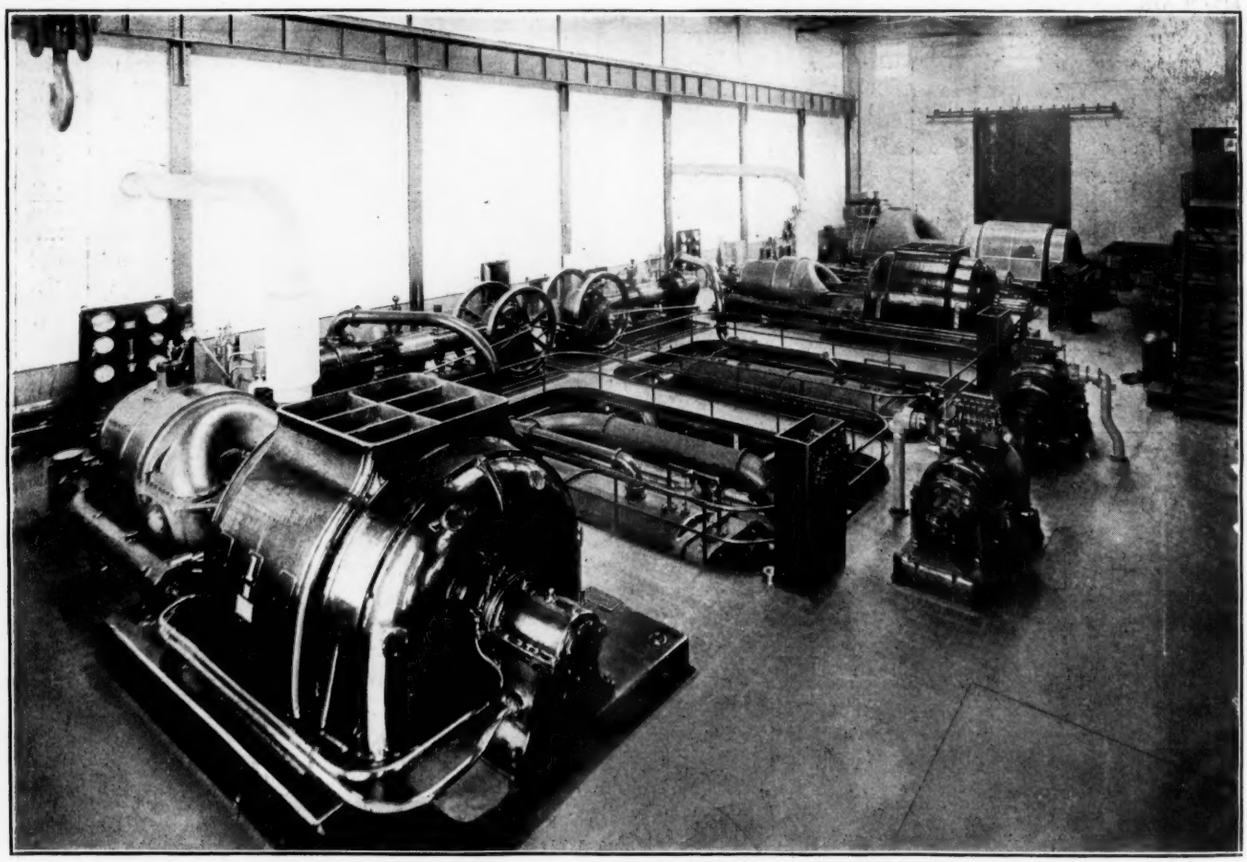
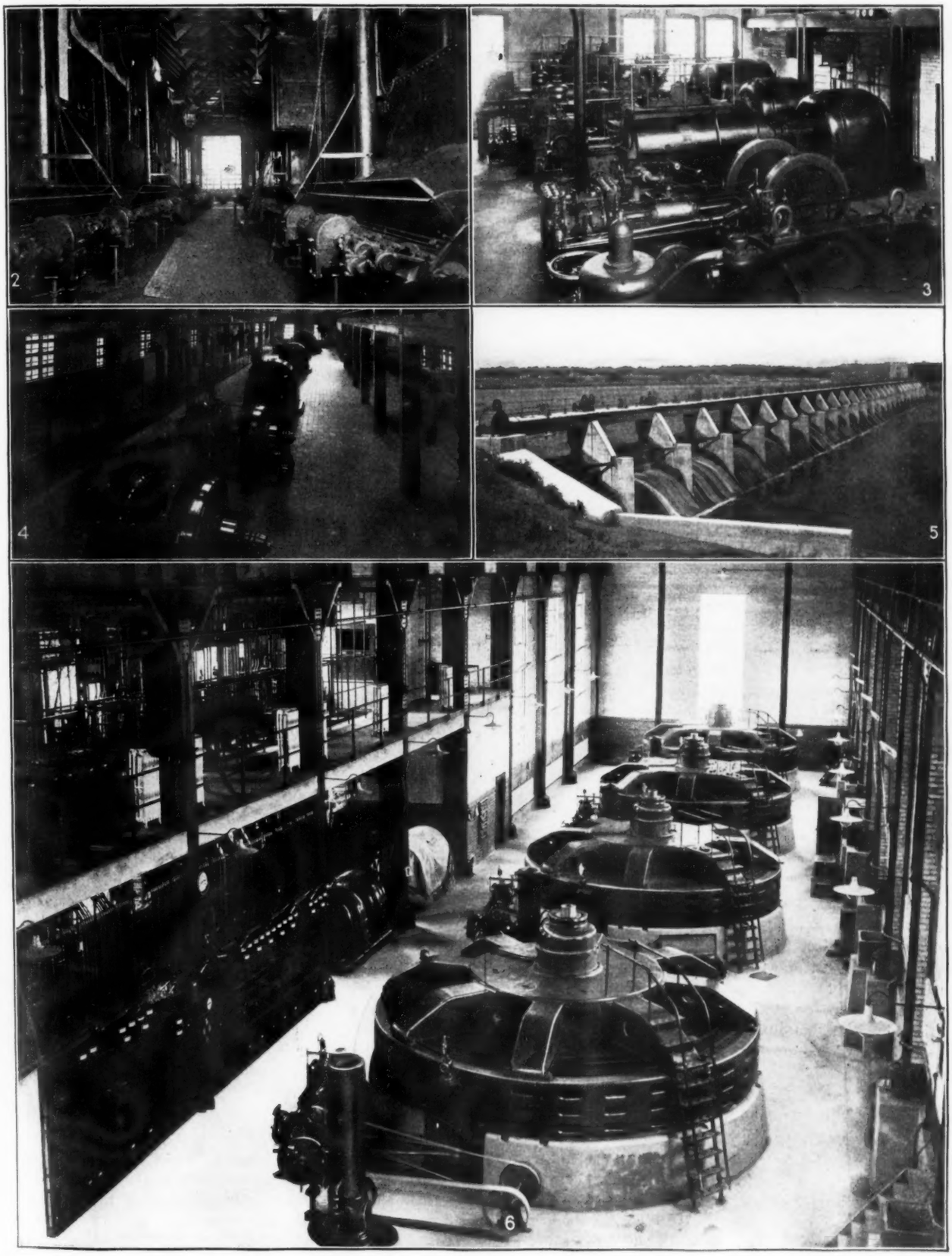


FIG. 1. TURBINE ROOM OF RIVERSIDE STATION



FIGS. 2 TO 6. POWER-PLANT VIEWS AT THE CONVENTION CITY

Fig. 2—Boiler room of the Riverside Station. Fig. 3—Turbine room of the St. Paul plant. Fig. 4—Water-power plant at the St. Anthony Falls. Fig. 5—Dam at Coon Rapids. Fig. 6—Interior of the Coon Rapids Station

zontal turbo-generators. The machines are motored in the same way as at Riverside, so that this station is also ready for instant service should the occasion arise. In winter the plant carries a large heating load and the electrical energy generated is limited to that which the heating steam will supply. Water-tube boilers to a capacity of 5,600 hp. are installed and served by underfeed five-retort stokers.

One of the water plants is situated in the heart of Minneapolis at St. Anthony Falls. It contains three units aggregating 2,000 kw. under a maximum head of 42 ft. A feature not common in late days is the employment of rope drives between waterwheels and generators. This plant is the principal distributing station of the Minneapolis system, all current being received and distributed from this point.

Most Modern Water Plant in Country

Of the various water-power plants operated by the company the development at Coon Rapids is the latest and is one of the most modern hydraulic installations in the country. The plant is only 11 mi. north of the business district of Minneapolis. The equipment now consists of five 2,100-hp. vertical single-runner waterwheels operating under an average head of 17.5 ft. at 62 r.p.m., each wheel being directly connected to a three-phase 60-cycle 2,300-volt generator. The plant is of particular interest as in 21 months of operation at the maximum capacity permitted by the supply of water, it has demonstrated that the thrust bearing may be placed over the generator without the slightest trouble from vibration. The dam is over 2,000 ft. long and is equipped with large Tainter gates. A feature is the provision of a permanent individual hoist for each gate. They are arranged for operation either by hand or motor, the latter being mounted on a truck traveling on rails along the dam. A simple coupling between motor and gate facilitates operation. Another feature is the use of Stoney-type gates, each moving on two trains of rollers, for closing the scroll cases. They are manipulated by a traveling crane.

Largest Steam Power Station in State

The steam plant of the Minneapolis Street Railway Co. is the largest steam-power station in the state. It has a capacity of 55,000 kw. made up of three 15,000-kw. vertical Curtis turbines and two 5,000-kw. machines of the same type. In addition a 20,000-kw. horizontal turbine is now on order. Originally the plant was equipped with 5,000-hp. vertical Corliss engines driving flywheel-type generators rated at 3,500 kw. Three-phase 35-cycle current is generated at 13,200 volts. The plant is reported to be the only large station in the country using the frequency mentioned. At the various substations the electrical supply is converted to direct current at 600 volts. All street railways in the Twin Cities and a number of suburban lines aggregating 440 mi. of track are supplied with current.

In the boiler room there are 28 boilers each rated slightly in excess of 500 hp. With one exception they are equipped with chain grates and the exception with an underfeed stoker having seven retorts. The operating pressure is 190 lb., and the superheat ranges from 125 to 150 deg. F. A feature is a special water-flow meter in each boiler-feed line. These meters are of home design consisting of a slotted cylinder containing a gravity plunger whose height is determined by the drop in pressure through the slots. The indicating mechanism is attached to the plunger.

The company also has two water-power plants. One, at the lower dam, has a capacity of 10,000 hp. in ten units which operate under a nominal head of 20 ft. This plant gets the full flow of the river. The Hennepin Island Station has a capacity of 12,000 hp. in four units which operate under a head of 56 ft. This installation is an excess-flow plant taking water from the same pond as the flour mills, the latter having the first rights. As much power as possible is obtained from the water plants, the balance being carried by the steam station, which is a full reserve plant capable of carrying the entire load.

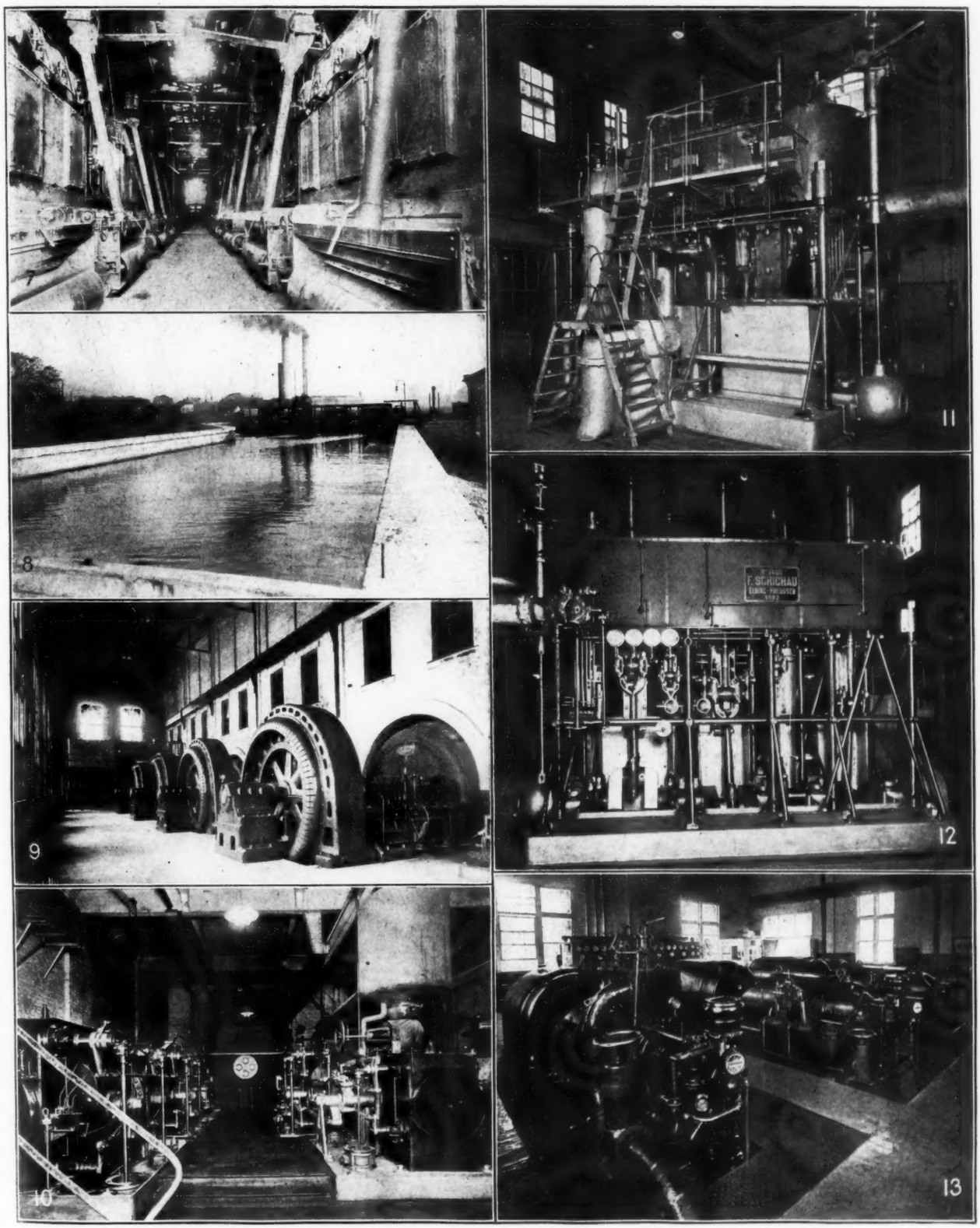
The world's greatest flour mills are in Minneapolis, and as the plants just described are in the heart of the milling district, it is only a step to the great mills of the Washburn-Crosby Co., which have a capacity of over 50,000 bbl. of flour per day. To supply power to make this enormous output the company has 12,000 hp. in a steam plant, 15,000 hp. is developed by water and in addition about 4,000 electrical horsepower is purchased. In the steam plant there is 6,000 hp. in heavy-duty Corliss engines, 1,500 hp. in a triple-expansion marine engine of German manufacture, and the balance of the steam power is developed by horizontal turbo-generators. The engines all drive the mills directly. Eleven Heine boilers, each rated at 500 hp. and equipped with underfeed stokers, supply the steam at a pressure of 185 lb. gage. When the plant is in full operation during the heating season, 250 tons of coal are burned per day.

Interesting Engine of German Make

One of the most interesting features in the plant is the German engine, which was built by F. Schichau, of Elbing, Prussia. It was exhibited at the Chicago World's Fair and purchased by the Washburn-Crosby Co. at that time. It has cylinders 28, 38 and 56 in. diameter, a stroke of 29 in. and a speed of 110 r.p.m. The only castings on the engine are the foundation plate and the cylinders. The former is 18 ft. long by 9 ft. wide, weighing 23 tons. It was cast in one piece. The steel frame is light, but strong and accessible. The high-pressure cylinder has a main piston valve and a rider cutoff valve located inside the piston valve and operated by a separate eccentric. Both the intermediate and low-pressure cylinders have balanced slide valves. On top of the valve chest of each of these cylinders is a small steam cylinder into which the valve stem extends, carrying on its end a piston. Steam from the intermediate receiver acts underneath the piston to support the weight of the valve stem, valve, eccentric rod and strap.

Another interesting feature is the use of a loose brass ring between the eccentric and the strap. This divides the wear so that it has been necessary to take up one eccentric a very little only once in the 23 years the engine has been in operation.

Although the engine is of the vertical type, the piston has tailrods with casings having spiral grooves. With this construction the wear is evenly distributed and the steam has access to the top of the tailrod so that the full area of the piston is effective. The high-pressure



FIGS. 7 TO 13. ANOTHER GROUP OF INTERESTING POWER-PLANT VIEWS

Fig. 7—Boiler room of Minneapolis Street Railway Co. Fig. 8—Head race and gates of Hennepin Island Street Railway plant. Fig. 9—Interior of Hennepin Island plant. Fig. 10—Four-cylinder triple-expansion Corliss engine at the Washburn-Crosby plant. Fig. 11—Rear view of Schichau engine at Washburn-Crosby plant. Fig. 12—Front view of Schichau engine. Fig. 13—Pillsbury steam-turbine plant

and intermediate cylinders are steam-jacketed, and the air pump, which is driven from the intermediate crosshead, has very little clearance, so that an average vacuum of 28 in. in a jet condenser is readily obtainable. The steam consumption runs about 13 lb. per i.hp.-hr. All journals are made of cannon bronze and lined with genuine babbitt. The main bearings have wick oilers, which have given excellent satisfaction, as all dirt and sediment is left behind in the oil box on top of the bearings. All other bearings are lubricated by a gravity system consisting of a supply tank on the side of each cylinder and piping to the points of lubrication.

Driven by beveled gears from the crankshaft, the governor controls the cutoff valve on the high-pressure cylinder. To reduce the metallic ring, lead was poured on the backs of the gears. Their operation is practically noiseless. In the front view of the engine will be seen the gages for indicating receiver and condenser pressures. There are also a tachometer and a revolution counter. Concentrated at one point at the left of the engine is a group of levers controlling all drain and auxiliary valves for starting when the high-pressure piston is on dead center. The injection and throttle valves are also controlled from this point. An innovation is the provision of two safety valves for each cylinder as a protection against water.

Horizontal Triple-Expansion Four-Cylinder Corliss Engine

Another interesting engine is a horizontal four-cylinder triple-expansion unit of American make. The cylinders are arranged two in tandem, one high- and one low-pressure cylinder on one side and the intermediate and other low-pressure cylinder on the other. If need be, the side containing the high-pressure cylinder may be operated independently. The engine is of the heavy-duty Corliss type rated at 2,600 hp., although at times it carries over 3,000 hp. It is connected to the mill by a rope drive. The cylinders are 24, 46 and 48 in. diameter, the two low-pressure cylinders being of the same size, and the stroke is 48 in. The speed is 104 r.p.m. The valves are partly located in the cylinder head to reduce the clearance. On the intermediate and both low-pressure cylinders they are operated directly from the rocker arms without wristplates. Both intermediate and low-pressure receivers contain superheating coils through which live steam passes. The steam consumption per indicated horsepower-hour is about 12 lb. Including the shaft, flywheel and receivers, the engine weighs 200 tons.

Across the river is the Pillsbury Flour Mills Co., which has the distinction of having the largest individual mill in the country and adjacent to this mill the largest wheat-storage elevator capacity in the world. The mills are served by an 8,000-hp. hydraulic plant and a modern steam-turbine plant consisting of two 2,500-kv.-a. and one 1,250-kv.-a. horizontal reaction turbines driving three-phase 60-cycle 2,300-volt generators. Barometric condensers serve the turbines. The boiler room contains seven 500-hp. horizontal water-tube boilers equipped with underfeed stokers. The pumps are of standard reciprocating type. In the mills are a number of large motors, one rated at 1,500 hp. and two at 1,000 hp., which are supplied with current at 2,300 volts. For the smaller motors the voltage is reduced to 440.

One of the best office-building plants in Minneapolis may be found in the First National and Soo Line Building. The equipment consists of one 380-hp. and two 187-hp. water-tube boilers provided with underfeed stokers. Two high-speed engines, 21x26-in., each connected to 170-kw. generators, supply with light and power the building in which they are installed and two other near-by buildings. The pumps for boiler feed and house service are of standard reciprocating type. Exhaust steam is used for heating, and with the exception of the bank, direct radiation is installed throughout.

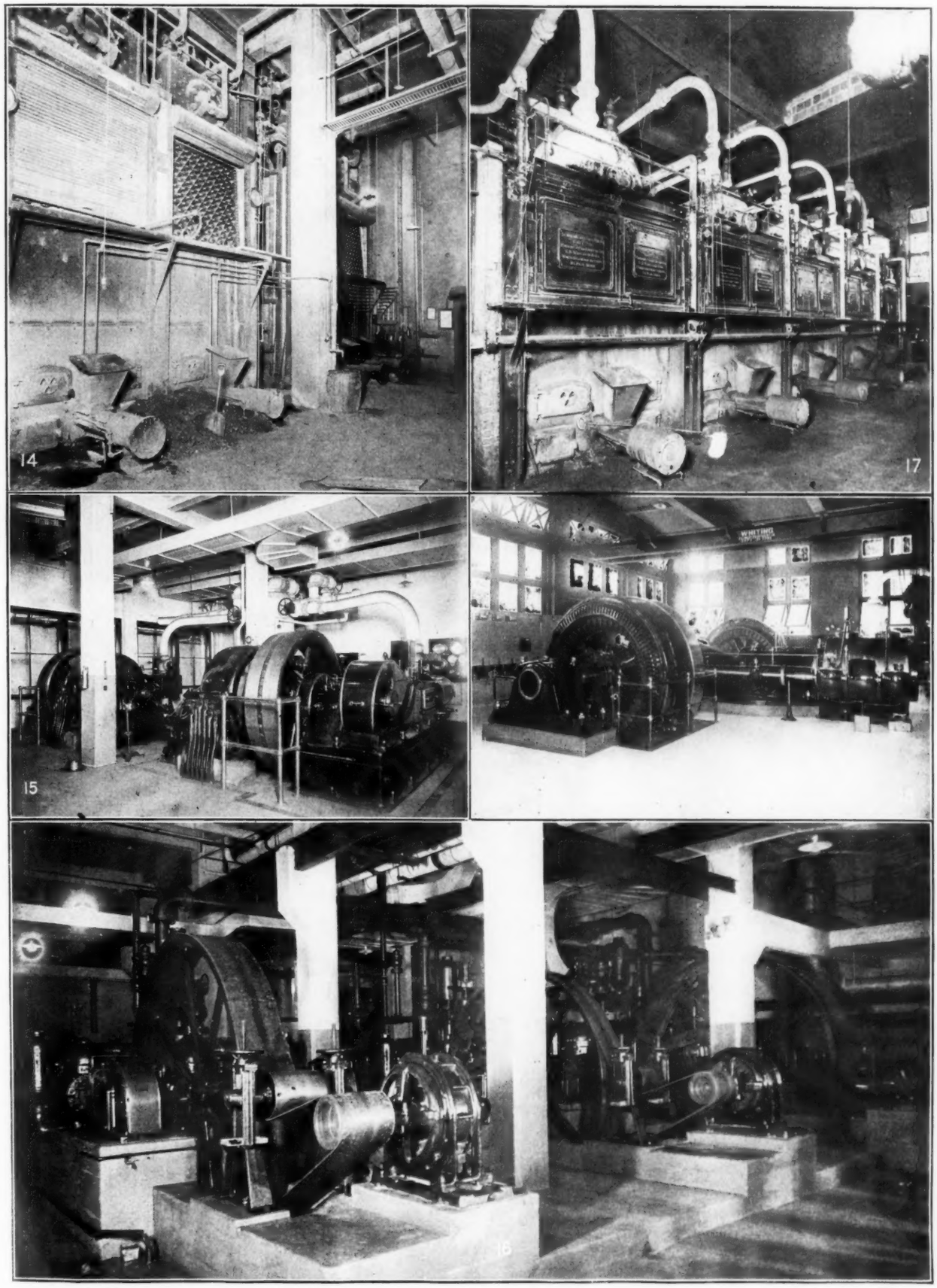
The Railroad Building, St. Paul

In St. Paul the leading office building is jointly owned by the Great Northern Ry., the Northern Pacific Ry., and the First National Bank. The Railroad Building, as it is called, occupies three-fourths of a city block and is 13 stories high. Although electrical energy and even steam is purchased, the plant has some interesting features—in particular the control of the house and elevator pumps. In addition to the lighting there is a total connected motor load of 1,160 hp. The 2,300-volt three-phase 60-cycle current purchased from the central station is received and distributed by a complete substation in the building of 1,000-kv.-a. capacity. The motors are chiefly of the 220-volt induction type, and many of them have remote control.

Water for the building is raised from a drilled well 400 ft. deep by an air lift which discharges it into an open tank in the sub-basement. Two house pumps take the water from this tank and discharge it into four house tanks of 5,000-gal. capacity each, located on the roof. When the water level in the house tanks falls to one-third capacity, a float-switch operates, throwing in one of the house-pump motors. If the water is drawn off faster than the pump supplies it, the level falls and a second float-switch operates to throw in house pump No. 2. Each of these pumps delivers 200 gal. per min., and the two easily supply the building, running intermittently. The water thus drawn from the surge tank lowers the supply, and when the tank is about two-thirds empty, a float-switch actuates the air-compressor motor, sending air into a receiver and then into the well to force an additional supply of water into the surge tank. When the water in any of the tanks reaches a level about 6 in. below the overflow, its respective float switch disconnects the pilot line and the motor stops.

Special Control of Elevator Pumps

There are 19 elevators in the building, 16 of which are of the hydraulic plunger type. The others are electric. The hydraulic elevators are all served from two sets of tanks in which the pressure is maintained automatically by contact-pressure gages controlling the operation of a bank of four motor-driven pumps. The tanks are connected and each set placed near its bank of elevators. Three of the elevator pumps are of the horizontal triplex type close belt-connected to motors. The fourth is a centrifugal pump directly connected to a 250-hp. motor. This unit is really a spare and only operates in emergency. Two of the triplex pumps are driven by 75-hp. motors and the third by a 200-hp. motor. Induction motors are used and for the horizontal triplex pumps are of the variable-speed slip-ring type shown in the accompanying illustration.



FIGS. 14 TO 18. BOILER AND ENGINE ROOMS OF INTEREST

Fig. 14—Boiler room of Soo office building. Fig. 15—Soo Building engine room. Fig. 16—Motor-driven elevator pumps in Railroad Building, St. Paul. Fig. 17—Boiler room of Northwestern Knitting Co. Fig. 18—Lentz engines at Northwestern Knitting Co. plant

Normally the maximum water pressure is 200 lb. When this pressure falls to 185 lb. one 75-hp. unit starts to operate. If the elevator traffic is heavy the pressure will continue to fall, and when it reaches 180 lb. the second 75-hp. pumping unit will cut in. If the pressure drops to 175 lb. the 200-hp. unit is automatically thrown into operation, and if there is a further reduction to 165 lb. the service of the centrifugal pump driven by a 250-hp. motor is required. When the pressure reaches 200 lb. all motors stop. Under ordinary conditions the two 75-hp. units are sufficient to meet the demands, running intermittently, but when the traffic is heavy the 200-hp. unit operates. It is thus evident that the various pumps operate at their most efficient load and only for the period during which their maximum services are required. As a consequence this elevator installation is unusually efficient and a credit to the consulting engineers responsible for its installation—Neiler, Rich & Co., of Chicago.

One of the "Show" Plants of Minneapolis

Returning to the Flour City—Minneapolis—an interesting manufacturing plant is that of the Northwestern Knitting Co., the maker of Munsing underwear. It is the largest plant in the country devoted exclusively to the manufacture of this product. The power station is one of the show plants of the city. The boiler room contains five 200-hp. horizontal and one 500-hp. vertical water-tube boilers, equipped with stokers of the underfeed type.

The boilers operate at 150 lb. gage pressure and, besides supplying steam to the engine room, furnish high-pressure steam for the laundry and bleaching departments. During the summer months 35 per cent. of the exhaust steam from the engines and pumps is used for heating water and for drying in the factory. In winter all the exhaust and a considerable amount of live steam is required. The heating is mostly indirect. There are four independent systems, each having its air washer, vento coils and fans. All water fed to the boilers is weighed, there are three checks on the coal weights and the current to each department is metered, so that the power-plant costs can be easily separated and proportionately divided. Water for boiler use and for the factory is pumped from a well 525 ft. deep on the premises. A considerable proportion of this supply passes through a softener.

Lentz Engines Giving Excellent Satisfaction

In the engine room there are two four-valve tandem compound engines each directly connected to a 165-kw. three-phase 60-cycle 220-volt generator making 164 r.p.m. These units are now held as a reserve, and the load is carried by either one of two Lentz engines, one directly connected to a 500-kw. generator and the other to a machine rated at 350 kw. In summer the peak load reaches 600 kw., and in winter it is approximately 200 kw. greater.

The bulk of the load is made up of induction motors one 125-hp. synchronous motor being operated to correct the power factor. The Lentz engines have been giving excellent satisfaction. The upkeep has been low, little attention is required from the operator, and a steam consumption ranging around 21 lb. per i.hp.-hr. is considered excellent for noncondensing operation.

The municipal light, heat and power and crematory plant should prove interesting. Last year 23,960 tons of garbage was burned and from the steam produced 605,680 kw.-hr. was generated to supply 212 luminous arcs for street lighting and light and power for the Hopewell Tubercular Hospital and the City Workhouse. In addition, steam for heating and laundry work is supplied the two institutions just mentioned. About 95 lb. of coal is burned per ton of garbage.

Before collection the garbage is wrapped in paper and allowed to drain. It is then gathered in tank wagons and conveyed to a railway loading station, at which point the full tank is removed from the wagon truck and replaced by an empty one. The full tanks are carried to the crematory on railway cars and are then conveyed by a crane to the incinerators. The crane being of the two-lift type, it is possible to lower the front end and raise the back end, so that the garbage can be easily raked into the incinerator. This method requires a minimum of handling and has given excellent satisfaction. A temperature of 1,250 deg. is maintained in the incinerators at all times, as at this temperature the incineration is complete and no obnoxious odors issue from the stack.

Equipment of Crematory Plant Which Burns One Ton of Garbage at a Net Cost of 53c.

The equipment at the crematory consists of three 50-ton DeCarie-type incinerators, one 330-hp. vertical water-tube boiler, one 220-hp. horizontal tubular boiler and one 125-hp. Heine boiler. A pressure of 75 lb. is carried in the incinerators, and this steam is used for heating, cooking and laundry work in the hospital and workhouse. It is also utilized to run the pumps. The gases from two of the incinerators pass into the dutch oven installed in connection with the vertical water-tube boiler, then through the boiler and out through an induced-draft fan to the stack. From the third incinerator the gases pass into the firebox of the horizontal return-tubular boiler. A steam pressure of 110-lb. gage is maintained in these boilers to supply the engine room. The Heine boiler is equipped with an underfeed stoker to burn coal as a safeguard against interruption of the supply of garbage.

The generating equipment consists of two 16x36-in. Corliss engines directly connected to 187-kv.-a. three-phase 60-cycle 2,300-volt generators and one 50-kv.-a. generator driven by a high-speed slide-valve engine.

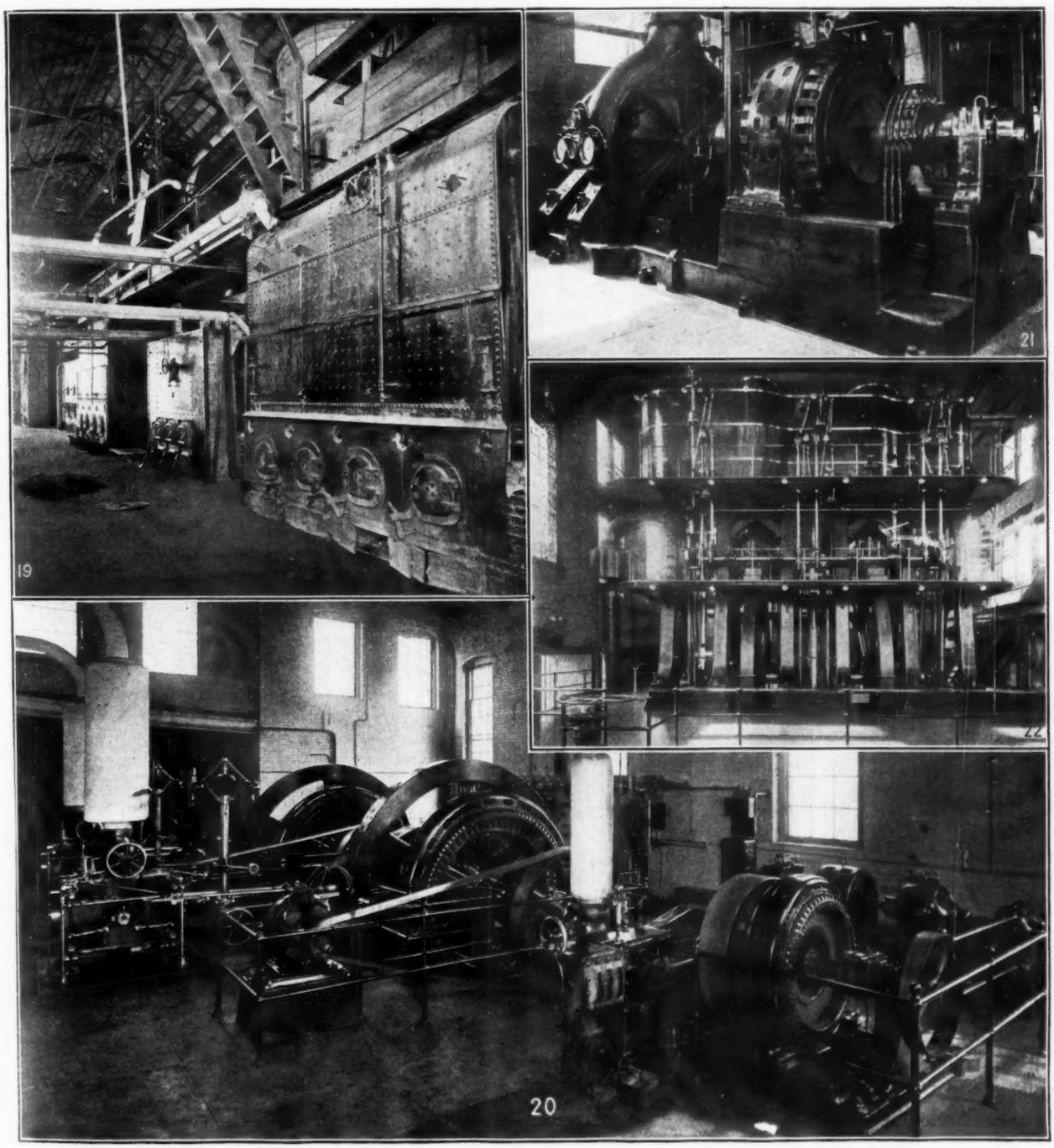
For the year 1915 the cost of burning the 23,960 tons of garbage was $28,036.50. The revenue from the steam amounted to $11,243.16. The operating charges on the lighting plant totaled $10,158.92, while the revenue was $14,191.51. Deducting the revenue leaves a net expense of $12,760.75, or a net cost of 53c. to burn one ton of garbage. Adding $10,100 as interest and depreciation on the crematory and lighting plant increases the cost of burning garbage to 97c. per ton. Complete data for 1915, giving operating and overhead expenses and the returns from byproducts and the sale of steam and electricity are available at the city hall.

Another interesting city plant is the Northeast Pumping Station, which has shut down its boilers and is buying power at an average cost of 0.381c. per kw.-hr. to do the pumping. This extremely low rate is explained by the fact that the load is continuous, 24 hr. per day, and for three months in the fall the pumping station

is shut down two hours per day during the heaviest peak load on the central station. The equipment is a 20,000,000-gal. centrifugal pump driven by a 1,200-hp. motor.

The steam equipment, consisting of two 15,000,000-gal. triple-expansion vertical pumping engines and the boilers, is held in reserve. When using the steam pumps, the cost per million gallons pumped to the reservoir averaged $7.18, as compared to $6.20 when using electric service. A large part of the difference is made up by the decrease in labor due to shutting down the boiler plant. To pump 1,000,000 gal. 1 ft. high requires 4.26 kw.-hr., costing 1.63c. The average electric pump head is 248.29 ft.

Although the photographs do not show it, there is a great difference in size between the two units. The centrifugal pump is installed in the basement and while its capacity is one-third greater it looks like an auxiliary to the big pumping engine. For a new plant, the motor-driven unit suggests a large saving in building, and a comparatively low initial cost. The lower efficiency is offset in this case by the low current cost.



FIGS. 19 TO 22. MORE PLANTS OPEN TO N. A. S. E. DELEGATES

Fig. 19—Incinerator and boiler plant. Fig. 20—Generating equipment at crematory. Fig. 21—20,000,000-gal. centrifugal unit at the Northeast Pumping Station. Fig. 22—15,000,000-gal. triple-expansion pumping engine at the Northeast Pumping Station

Electrical Machine Bearings

By Gordon Fox

SYNOPSIS—A discussion on the different types of bearings used, the materials from which they are made and their action under operating conditions on electrical machines, different systems of lubrication and ways to prevent oil creepage.

Bearings are a necessary part of all rotating electrical machines. The prime functions of the bearings are to maintain the relative positions of stationary and revolving parts, to support the weight of the moving element and to receive the side thrust or end thrust incident to the drive. Direct-connected motors will ordinarily have little side pressure on their bearings. Where excessive side or end thrusts may occur, flexible couplings may be used to transfer the stresses to the driven machine which is designed for them. Belted or geared motors or generators, in addition to the weight of the moving parts, have considerable side thrusts to care for. In determining the amount of side pull due to a belt the formula,

$$\textit{Belt pull in lb.} = \frac{hp. \times 33{,}000 \times 1.25}{r.p.m. \times \textit{pulley diameter in ft.} \times \pi}$$

may be used. The 25 per cent. increase is allowed for tension on the loose side of the belt.

In the cases of a geared machine the tangential force at the pitch line is obtained by the formula,

$$\textit{Force in lb.} = \frac{hp \times 33{,}000}{r.p.m. \times \textit{pitch diameter in ft.} \times \pi}$$

So far as the bearing action is concerned, these forces may be considered as a direct thrust applied at the center line of the gear or pulley. In figuring bearing pressures the basis taken is the unit of projected area. This corresponds to the cross-section of the shaft within the bearing limits. The pressures per square inch of projected area allowed for motor and generator bearings under ordinary practice range from 50 to 90 lb. Where cooling oil is circulated, as in turbine bearings, higher pressures may be used; it is well not to exceed the value 90 lb. per sq.in. It will be seen from this discussion wherein pulley sizes are limited. A small, wide pulley requires higher belt tension and greater pull to transmit a given load, and this force is applied at a distance farther removed from the bearing. Therefore bearing pressure and loss increase as the pulley size is reduced.

Materials Used for Bearings

The frictional loss in a bearing depends upon the peripheral speed of the shaft. Surface speeds of 30 to 50 ft. per sec. are ordinary values, while 100 ft. per sec. is a very high value. Since the bearing loss increases directly with the speed, it is desirable to restrict shaft diameters to obtain low bearing speeds.

Two general classes of materials are used for bearings of electric machines. They may be classed as low-melting metals (babbitts) and high-melting metals (bronzes). The fundamental idea of the use of a bearing material softer than steel is to prevent injury to the shaft during periods of starting and stopping, when the oil film is broken. Instead of a grinding action, we obtain with bronze or babbitt a yielding effect which simply smooths out the surface. This action is particularly pronounced with babbitt; here the surface soon becomes smooth and burnished, encouraging a uniform oil film with a minimum of running friction. Babbitt has the advantage of being easily worked and renewed, together with a low coefficient of friction. It has the advantage of such a low melting temperature that it is likely to run out when overheated. However, an equal amount of heating will also be disastrous to bronze bearings, but in a different manner. Babbitt is long-wearing and shows little loss of material even after long service.

Babbitt bearings require an outer shell to retain them. This shell is usually made of cast iron, but is sometimes made of bronze so that, if the babbitt melts out, injury to the shaft will not follow. The babbitt-lining thickness is about $\frac{3}{16}$ in. in the small bearings and reaches a depth of about $\frac{3}{8}$ in. in the larger ones. Anchor grooves, dovetail and drilled-hole constructions are used to prevent rotation of the babbitt in the shell and also to take up the end thrust. Because of the requirement of an outer shell, babbitt is not ordinarily used for small motors; here a plain bronze or white-metal sleeve is satisfactory, more simple and less expensive. The dividing line between bronze and babbitt bearings varies with different manufacturers, but in most cases corresponds fairly closely with the change from solid to split bearings. Nearly all sleeve journals are bronze, while practically all split bearings are babbitted. Bearing sleeves are generally held against the tendency to rotate by dowel pins driven through the housing into the sleeve.

The Lubrication of Bearings

Bearings of electrical machines were at first lubricated by miscellaneous devices such as grease cups, drop feeds, capillary wires, wicks, wipers and vibrating needles. These methods aimed to use the lubricant but once; they were irregular, wasteful, required continual attention and supplied the minimum allowable of lubricant. Today nearly all horizontal electrical machines are ring-oiling. Oil rings about twice the diameter of the shaft rest on it and are rotated by frictional contact. Sometimes chains are substituted for rings; little is gained except space. The delivery of oil from a ring is governed by its size and speed. The weight of the ring depends somewhat upon the peripheral speed of the shaft; a heavy ring delivers more oil, secures better tractive effort and jumps about less than a light ring.

For high speeds too large a ring causes too great oil delivery and throws oil into the upper bearing housing. Rings may be either solid or split, the solid type being used on small machines which are easily dismantled, while the split type is employed in the very large bearings. Oil rings must be made of bronze to avoid magnetic difficulties which would occur with steel rings. They must be perfectly round, otherwise they may run crooked and jam or else lodge in the eccentric position. The quantity of oil delivered is nearly independent of the depth of immersion of the ring in the oil well, if the depth is not

too small. The delivery depends largely upon the viscosity of the oil as affected by its temperature; this fact not infrequently leads to a hot bearing. A little overheating thins the oil, its delivery is thereby greatly decreased and it cannot maintain a perfect film. The addition of cylinder oil and graphite is beneficial in such cases. The cylinder oil adds viscosity and enables the ring to grip the lubricant. The heavier body also aids in maintaining the film. Although cylinder oil is excellent for nursing a warm bearing, its use in a cool bearing is not advised, as it is too thick and heavy at ordinary temperatures. Because of the variation of viscosity with temperature, it is advisable to use a lighter grade of oil in winter than in summer, particularly upon motors located outside or in unheated buildings.

To assist the formation of a uniform film, oil grooves are usually cut in the bearing sleeves. These grooves should lead away from the point of entrance or source of supply diagonally outward and in the direction of rotation. Since motors are for either rotation, the grooves are cut symmetrically for both directions. The edges of the grooves should be beveled to aid in the formation of the oil film. Sharp edges tend to cut or peel off the oil, preventing its entrance. Oil grooves should not be to oil rotting, and it is good practice to round this corner as a partial preventive.

Oil reaches the commutator or other part of a machine by creepage along the shaft and out from the bearing, followed by radial travel encouraged by centrifugal force. Oil creepage from a bearing is usually due to a slight suction incident to the ventilation system of the machine, air being drawn in about the ends and expelled radially at the center. High-speed, well-ventilated machines are most liable to oil creepage. To prevent the leakage of oil from bearings some provision is made in nearly all machines. Fig. 1 shows grooves near the ends of the sleeve which serve to lead the oil into the reservoir. Any oil that passes this point encounters the oil-throwing guards shown on the shaft in the same figure. Here centrifugal force leads the oil to the summit of the ridges whence it is thrown into the reservoir.

The foregoing provisions to prevent oil leakage are made in nearly all electrical machines, but do not always prove entirely effective. It then becomes necessary to provide other preventives, such as a disk on the shaft just inside the bearing, known as an oil slinger. A second curative method utilizes a leather or felt wiping washer, which is attached to the end of the bearing and wiping

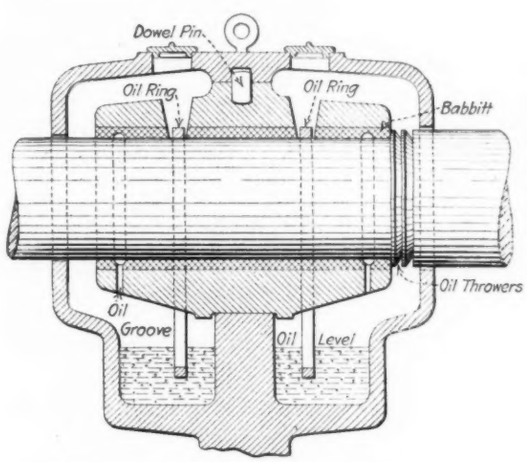


FIG. 1. RING-LUBRICATED BEARING

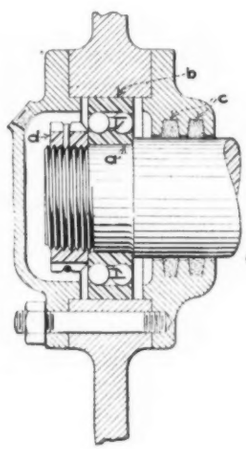


FIG. 2. MOTOR BALL BEARING

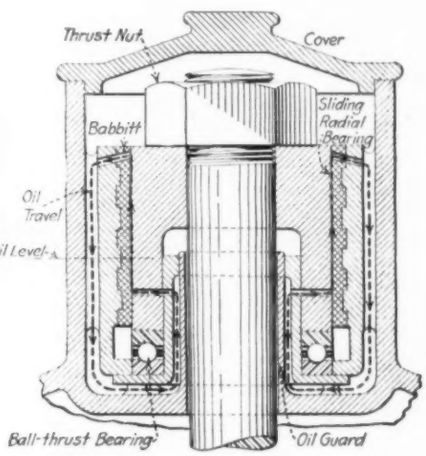


FIG. 3. BALL-THRUST BEARING

cut in the zone of maximum pressure—usually the side or bottom of the bearing. The grooves are therefore usually confined to the top shell of the bearing.

Where gravity or oil-pump systems are employed, they are usually in connection with oil-ring systems, the flow of oil being merely for cooling purposes. The oil-feed pipes pass through the side of the bearing, one feeding the entrance trough, the other receiving the overflow from the oil well. Sufficient oil must be fed to maintain an operating oil level above the overflow at all times to enable the rings to supply their full quota of lubricant to the bearings.

A plenteous supply of lubricant is desirable within a bearing; outside of the bearing it at once becomes a nuisance and a source of possible injury. Much of the insulation used on electrical machines is affected by oil. Rubber insulations slowly dissolve, while fibrous material soaks up the oil, accumulates dirt and lowers insulation resistance. This is one of the chief causes of mica carbonization in the commutator, with its accompanying evils—short-circuits and grounds. Particularly at the outer corner of the commutator the segments seem prone upon it, and is held in place by a sheet-metal washer screwed to the bearing housing. The leather or felt washer cuts off the air currents and also wipes back any oil that may reach it. The oil ring not only lifts oil to the shaft, but sometimes throws it out into the bearing housing, often causing a continuous film of oil to form. If this film reaches to the bearing split, it may easily be sucked around on the shaft and thence into the machine. To prevent this an oil guard is sometimes cast in the upper half of the bearing, extending below the bearing split and inclosing the oil ring. If such provision is not made, it may sometimes be added to a troublesome bearing by means of sheet-metal guards formed and attached to the upper cap. If this is not possible, the addition of a pressboard shim between the halves of the bearing housing may serve as a seal to prevent excessive leakage.

When the armature or rotor of an electrical machine is exactly central with respect to the bore of the outer frame, the magnetic pull is equalized in all directions. If the rotor be slightly out of center, the magnetic distribution is unbalanced, which may result in electrical

difficulties. In a direct-current machine sparking is likely to occur because of local currents through the brushes. In induction motors the air gap is so small that but slight eccentricity is necessary to permit rubbing. Eccentricity also causes unbalanced magnetic pull, which throws added pressure upon the bearings and encourages further wear in the same direction. In large machines advantage is taken of unbalanced magnetic pull to lessen the gravity load on the bearings, by placing the rotors slightly above the center of the bore. This is permissible with alternators having sufficiently stiff frames and with large direct-current generators equipped with equalizing rings which overcome the detrimental effects of cross-currents. The air gap of large units is adjusted by movement of the outer frame. Some makes of self-contained induction motors have air-gap adjustment, the bearings being slightly shifted to accomplish this purpose. This is a desirable feature. Small motors are seldom arranged for bearing adjustment, since wear is slow and replacement can be made for a comparatively small expense.

Ball bearings, although not extensively used, are meeting with some favor for application to electrical machines. The argument most commonly presented as favoring the use of ball bearings is power saving through decrease of bearing losses. That this feature alone is not a deciding factor may be appreciated from the fact that, in most machines, bearing friction does not exceed 2 per cent. of the rated load and affects the efficiency to a correspondingly small degree. One advantage of ball bearings is that the friction is independent of the viscosity of the lubricant used.

The Advantages of Ball Bearings

Oil, grease or vaseline is used in ball bearings for lubricating purposes and to prevent corrosion. The static friction of ball bearings is low, and the resistance at starting is much less than that of sliding bearings: they seldom run hot, hence avoid delays incident to bearing trouble and fire risk arising from hot bearings. Well-constructed ball bearings can adjust themselves to slight deformation of the shaft. They can be used to advantage where little end play is desired, as for grinders.

An advantage of ball bearings which may be important is the small space they occupy. Sliding bearings are usually designed with a sleeve length 2½ to 3 times the shaft diameter, the pulley end having usually the longer bearing. The space occupied by ball bearings is generally about one-half the shaft diameter, and their use thus permits a considerable reduction in the over-all length of a motor. This reduction, amounting to 25 per cent. in some cases, and in the application of electric motors to machine tools may be a point of some importance, permitting a compact installation.

A sectional view of an ordinary motor ball bearing is shown in Fig. 2. It will be noticed that the inner race *a* is secured to the shaft by a nut *d*, consequently there is no wear on the shaft itself. The outer race *b* is shown with an allowance made to permit end movement. The inner end of the housing has felt wiping washers *c* to prevent outflow of oil or entrance of dirt. It is imperative that ball bearings be kept clean. No oil well is provided, as a minimum of lubrication is necessary. This is a point of vantage for motors mounted on ceilings or in other inaccessible places.

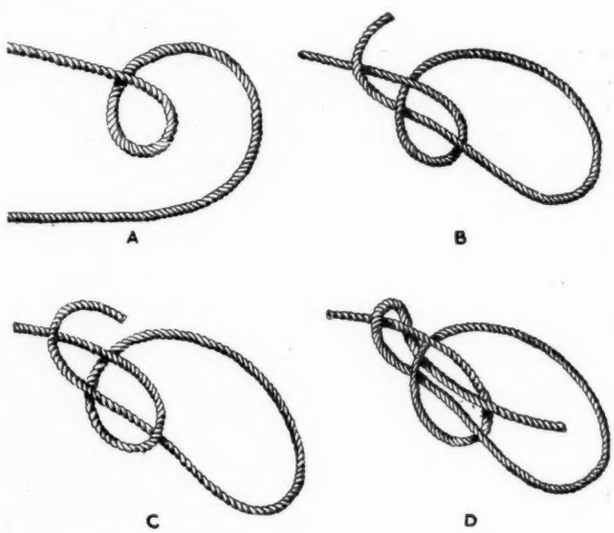
Ball bearings of good quality are strong and durable and may be depended upon to withstand at least the same amount of side pressure, as could be expected of a sliding bearing under the same circumstances. They are almost universally used to receive the end thrust of the rotor of vertical motors. The bearings of these motors are often required to support considerable weight in addition to that of their own rotors. A single thrust bearing is provided, being located in the upper housing. Fig. 3 shows the construction employed by one motor builder. An oil well is provided, and through centrifugal action the oil is made to circulate upward into the sliding bearing, then outward and back into the reservoir. A sleeve about the shaft reaches above the normal oil level and prevents entrance of oil into the machine.

The construction of vertical bearings is modified in different makes, but the same general principles are used. In some both end thrust and side thrust are cared for by ball bearings. A radial set and a thrust set are employed in the upper bearing, and a radial set alone is inserted in the lower bearing.

Tying a Bowline Knot

By Fred West

The "safety first" slogan has given a new meaning to many an action in power-station erection, repair and operation. Generally there is more than one way to do a thing, and herein comes the demand to be careful. For instance, the simple matter of tying knots when making slings may either make or prevent a lot of trouble.



TYING A BOWLINE KNOT BY TWO METHODS

Take the example of the useful bowline knot that should be understood by power-station mechanics. To make this knot, form a loop, or bight, as at *A* in the illustration. Next bring the end of the rope through the bight, which may be done in two ways: Pass it down through from the top, as at *B*, or up through from the bottom, as at *C*. In either case the end is carried around the main rope and then passed up through the bight, as at *D*.

Both of these methods of tying the bowline are good and safe, but there is a difference between them when the untying has to be done. The first one is easily untied; the second draws hard and tight.

Factors That Influence the Selection of a Condenser

By H. J. Macintire

SYNOPSIS—The object of the article is to bring together all the important factors controlling the selection of a condenser and to give a method of analysis that will enable one to arrive at a correct solution for any set of conditions.

Among the questions of first importance are the cost, the temperature and the purity of the cooling water. The cooling water should be plentifully available and near the site of the power plant. There should be no possibility of a water famine, and the pumping cost should be nominal. The matter of the temperature of the water is next in importance, being a decided factor in the vacuum that can be attained and maintained as well as in the cost of pumping. The back pressure on the prime mover is determined by the vapor pressure existing in the condenser, and this is obtained by the temperature of the condensate. For instance, if the temperature in the condenser is 70 deg. F., the back pressure on the turbine assuming no losses due to friction, would be 0.3626 lb., provided no air is present. Unfortunately air is always present to a greater or lesser amount—brought in by leaks through the glands, by being absorbed in the boiler feed water and by the porosity of the cast-iron pipes composing the low-pressure end of the system. The addition of air increases the total pressure in the condenser according to Dalton's law. The temperature of the condensate can never be cooled as low as the temperature of the cooling water leaving the surface condenser, but it may be brought to within 5 deg. F. of this temperature. The cooling water must, in condensing the steam, carry with it the latent heat of vaporization of the steam. Evidently a small amount of water may be used if raised considerably in temperature, or a large amount of water may be used to be raised but a few degrees. In the latter case the vacuum will be better, but the pumping cost will be considerably greater.

Pure Feedwater Important

Besides these factors there is the question of the boiler feed. One must remember that even fresh water has impurities—salts held in solution, acids or even solid materials. With but a small amount present one knows that continual evaporation will make the residue concentrated. The residue may be removed from the boiler by periodic blowing off, but scale will form nevertheless, requiring frequent tube cleaning, or foaming may occur. A feed water free from impurities is therefore imperative. Where boiler feed water is expensive or impure, recourse may be had to the condensate from the turbine or engine, though if the latter is used there must be some means employed to get rid of the oil from the exhaust steam, as by the use of an open heater or otherwise.

Finally, in our analysis of the location of the power plant there is the question of the cost of the fuel, which is often as much as 50 per cent. or even 75 per cent. of the total power-plant cost. How this affects the choice of the equipment will appear later. As was said before, condensers may be divided into two general types—the jet and the surface condenser, the former being a mixer and the latter a metal-surface design.

Except for special cases, the jet condenser throws away the condensate, which in every case becomes intimately mixed with the cooling water. The boiler feed must be taken from the source of the makeup water. This type of condenser has two distinct types of design—the high head and the low head.

The high-head condenser, based on the principle of the barometric tube, is one of the oldest designs and has been successful as a steam-engine auxiliary. It is raised some 34 ft. or more above the tailrace. As its name implies, it overcomes the pressure due to the atmosphere by means of the weight of the water in the long tube, and the condensed steam and the cooling water flow out freely. The vacuum formed in the condenser tends to lift the condensing water into the mixing chamber and could almost

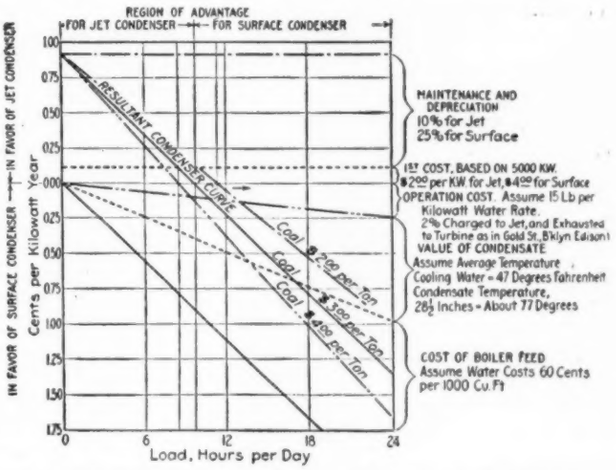


CHART TO ASSIST IN SELECTION OF CONDENSERS

do so were it not for friction. A small amount of power has to be used to lift the water into the mixing chamber.

Besides the power for lifting the water, most designers of this type of condenser add an air pump, an auxiliary absolutely required in all other forms of condensers. In this connection we must remember that the vacuum is obtained by the condensation of the steam, and the air that leaks in or comes in with the condensing water must be removed to obtain satisfactory results.

In the case of the jet condenser a small amount of air comes in with the makeup water, as seen in Table 1, and

TABLE 1. ABSORPTION OF AIR IN WATER

(Winkler, 1904)

Temp., Deg. F.	Cu.Ft. Air per 1,000 Cu.Ft. Water @ 29.92 In. Hg	Temp., Deg. F.	Cu.Ft. Air per 1,000 Cu.Ft. Water @ 29.92 In. Hg.
32	29.18	68	18.68
50	22.84	86	15.64

passes from the boiler with the steam. Where the boiler feed is heated by means of an open heater, however, a considerable amount of the air is driven off, the amount depending on the temperature to which the feed water is heated in the heater. Leaks in the low-pressure side of

the prime mover and the condenser, the piping, etc., are causes for the admission of air into the condenser. These leaks are present with all installations and all designs, but (being very hard to locate) are found especially in cases where there is a long run of pipe between the turbine and the condenser, as is inevitable where the barometric tube condenser is used. This is one reason why not much over 27 in. vacuum can be expected with such a layout. The third, and by far the most important, source of air is in the condensing water. It is usual to consider, though not strictly true, that all the air in this cooling water is released from solution as soon as the water enters the mixing chamber, comes into contact with the low-pressure present and has its temperature raised by the steam. Taking a case where 50 lb. of cooling water is used per pound of steam and assuming 2 per cent. free air, by volume, present in the water, 50/40,000, or 1/8 per cent., of the weight of the steam is air. Considering this air alone at 70 deg. F., the piston displacement per pound of steam becomes 12.5 cu.ft. at 26 in., 16.8 cu.ft. at 27 in., 25 cu.ft. at 28 in. and 50 cu.ft. at 29 in. vacuum, referred to a 30-in. barometer. Increasing the injection water to 100 lb. per pound of steam, we get an air-pump capacity that is twice as great, so far as this consideration is concerned.

The air is, as a rule, removed by some form of air pump. The manner of the removal determines the design of the condenser. This may be grouped under the head of either a parallel or a counterflow, referring especially to the direction of the air with respect to the cold cooling water. Again, generally speaking, the counterflow and the reciprocating, and the parallel and entrainment pumps are associated together. The reason for this may be brought out by another example.

TABLE 2. VAPOR PRESSURES AND AIR PRESSURES

Deg. F.	Vapor Pressure, Lb. per Sq. In.	Air Pressure, Lb. per Sq.In.	Weight of 1 Cu.Ft. Vapor	Air	Total
101.9	1.002	0.003	0.003009	0.0000145	0.003023
101.0	0.975	0.030	0.002933	0.000149	0.003078
100.0	0.946	0.059	0.002851	0.000285	0.003136
95	0.813	0.192	0.002469	0.000937	0.003406
90	0.696	0.306	0.002130	0.001501	0.003631
85	0.594	0.411	0.001832	0.002044	0.003876

In the table the total pressure is assumed to remain constant at 1.005 lb. abs. A decrease in temperature of the vapor and air mixture condenses a portion of the vapor and decreases the vapor tension of the remainder. As the total pressure has to remain constant, the partial pressure of the air increases as shown. In consequence the density of the air increases. For instance, were it possible by means of some suitable counterflow arrangement of cooling water and steam to cool the mixture to 100 deg. F., the volume of the air, and therefore the piston displacement of the air pump, would be reduced to $^1/_{19}$ of that required at 101.9 deg. F. Likewise, if the temperature could be made 85 deg. F., the reduction would be $^1/_{141}$. In the entrainment pump this cooling is occasioned automatically by means of the water pistons, as the water used would be the coldest available, whereas the temperature of the condensate (and therefore the vapor pressure of the steam) is determined by the exit cooling water in the case of the surface condenser and by the temperature of the mixture in the case of the jet condenser.

To resume, the jet condenser has about twice as much air to remove as the surface condenser. In addition, the condensate and cooling water have to be removed against the pressure of the atmosphere, the condensate being lost for boiler-feed purposes.

The surface condenser is used particularly where the cooling water is not suitable for boiler feed. The condenser is made up of a large number of small tubes of brass or of special composition for the circulation of the cooling water. The steam comes in contact with the outside of the tubes. The cooling-water pump requires power to overcome the frictional head only—usually some 6 to 12 ft. The amount of water is greater than in the case of the jet condenser, because the temperature of the cooling water leaving it is considerably lower than the temperature of the condensate, for otherwise an infinite surface or an infinite amount of water would be required.

Air Film on the Tubes

If air were not present, condensation of the steam would be almost instantaneous. In reality a small amount of air comes in with the steam. As the steam in contact with a certain tube condenses, a film of almost pure air is left in contact with the tube. This film acts as an efficient insulator; but fortunately the succeeding steam subjects the tube to a scouring action, and the vapor is driven on much richer in percentage of air. If the colder water came in at the top and left at the bottom, practically all the condensation would take place on the upper tubes. With the reverse taking place, the richer mixture of air and vapor descends to a tube region containing colder water, more steam is condensed, and the richest mixture (whose combined density may be found by calculation to be greater than the entering mixture by about 25 per cent.) gravitates toward the bottom. A connection to the air pump at or near the bottom is rational because of the assistance due to gravity, and, as in most cases with a top exhaust opening, the steam flows straight through the condenser without change of general direction, unless, of course, it is baffled.

It has been brought out that the action of air is to make the lower vapor temperature less than the temperature in the upper part of the condenser. This may be a fraction of a degree, or it may be as much as 20 or 30 deg. The condensate at each successive layer of tubes will also be of corresponding lower temperature. As the condensate is to be returned to the boiler, the hotwell temperature is desired as high as possible. There would be an advantage if this condensate could be drawn off to the hotwell as soon as it is condensed by means of a suitable arrangement of baffle plates. Without the baffle plates the condensed steam drips from tube to tube and, being hotter than the condensing temperature at the lower tubes, the action of the condenser is retarded and the mean hotwell temperature is lowered at a loss of fuel.

Baffles in the Condenser

The use of baffles in the condenser is not usually recommended. The reason is that it is not economical to use for turbine installations a condenser that allows a frictional drop of pressure of more than $^1/_{10}$ in. of mercury. The baffle plates, as applied to rectangular and circular cross-sectioned surface condensers, offer too great a resistance. In addition, unless the baffle plate is so arranged as to keep the flow of steam and air always parallel to the baffle, dead spaces will be formed, rich in air, which practically subtract that portion of the tube area from the total effective area. The more accepted practice is to use no baffles at all, but to space the tubes farther apart at the steam entrance or

to provide lanes into the center of the tubes so as to allow freer access for the steam to the cooling surfaces.

Consider the choice of a condenser. The high-head condenser is bulky, inconvenient and unreliable, as a rule, for steam-turbine installations. The choice then rests between the low-head jet and the surface condenser. The main consideration is in regard to the feed water. Where salt water only or water equally unsuited for boiler feed is available, the surface condenser should be selected. If the cooling water is acid, it would be cheaper to neutralize the boiler feed and use the jet condenser than to replace corroded condenser tubes.

The advantages of the low-head jet condenser compared with the surface condenser are lower first cost ($2 as compared with $4 per kw. for the 5,000-kw. size), lower maintenance, less space (the surface condenser requires space for replacing of tubes) and ability to use any kind of water that can be pumped. The advantages of the surface over the jet condenser are less power (about 40 per cent.) required for the auxiliaries, the condensate may be returned to the boiler at the temperature of the hotwell, no danger of flooding the condenser and therefore of the turbine, less air to be removed and, unless the makeup water is very pure, fewer boiler-tube cleaning troubles. The diagram is calculated for the above factors, taking the conditions of a 5,000-kw. design, coal at $2, $3 and $4 per ton. The point brought out in the diagram is that for low load factors the jet condenser is always to be preferred, whereas for central stations where the load extends over 12, 18 or more hours per day the jet condenser will show a loss. The point at which the jet condenser shows no advantage varies with the cost of fuel, as shown.

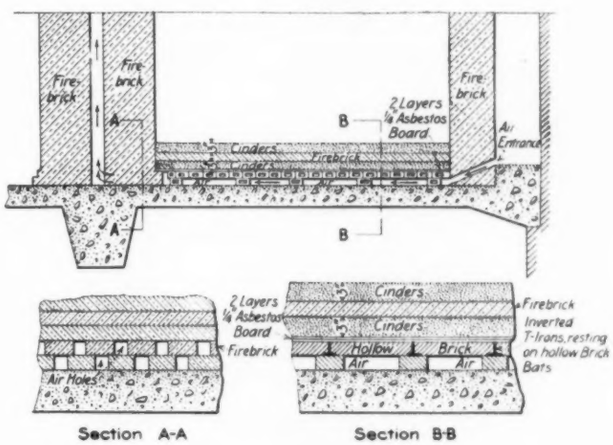
Finally, as regards examples of condenser selection: The condenser for the municipal standby station in Seattle, Wash., is of the jet type. The station is mainly for occasions when trouble occurs on the transmission lines or at the dam where the hydro-electric station is located. Usually the load factor is small—less than two hours per day at full load, during the time of the evening peak load—and therefore the use of the jet condenser is justified. This is even more so in the cases of the standby stations of California (see "Transactions" of N. E. L. A., 1915). Take examples in Chicago, Detroit, New York, etc., however, where steam stations only may be used and where the load factor is high on account of careful contract making. These stations use the surface condensers almost invariably because, first, the load factor is high, and, second, fuel is expensive. In New York this is true even in spite of the heavy replacement cost of condenser tubes. The surface condenser cannot be used to advantage in Pittsburgh and other cities similarly located, however, because of the acid in the river water.

Concrete-Floor Insulation

Two new boilers were installed on a reinforced-concrete floor. After being used for a short time cracks were noticed in the concrete, caused by expansion due to the excessive heat. A little later a brick wall that separated the two boilers had to be taken out because the heat was so intense that the wall started to give way. This wall was 34 in. thick, with outer layers of firebrick and the interior of common brick, and rested on the concrete floor. The concrete under the wall was found to have begun to dehydrate. On taking up some of the insulation under the combustion chambers, which consisted of a 1-in. layer of 85 per cent. magnesia over the concrete, two layers of common brick and a top layer of firebrick, it was found that neither the common brick nor the firebrick were injured, but that the magnesia had become pulverized and the concrete dehydrated on the surface.

Asked to suggest some method of overcoming the difficulty, the Ferro Concrete Construction Co., Cincinnati, Ohio, proposed the method shown in the accompanying cross-section. The method depends for its protection largely on the circulating air space between the combustion chamber and the floor, and in the separating wall. Holes were punched through the outer wall to allow the outside air to enter, pass under each boiler setting and up through the slot in the center wall.

This air space under the boiler setting was formed by inverting 2½x2½x$\frac{5}{16}$-in. steel tees, placed the length of a brick apart, and held above the concrete by hollow brick



DETAILS OF CONCRETE-FLOOR INSULATION

bats placed under the tee sections approximately 2 ft. apart. The tees were covered by a layer of hollow brick, thus forming an air space above the brick. The surface of this brick was flushed with a sealing of clay, which was covered in turn by two layers of ¼-in. asbestos board, section *BB*. Over the board was placed a 3-in. fill of cinders, a layer of firebrick and another 3-in. fill of cinders. This construction provided not only a circulating air space, but a dead space formed by the hollow brick. Particular care was taken that no air could get from this ventilating air-space through the insulation into the furnace.

Under the brick wall, the air space was formed by placing the two lower layers of brick as shown in section *AA*, leaving an air space between each brick. When the wall itself was replaced, it was built of firebrick.

The boilers have now been in operation for some months and no further trouble has been experienced. A vigorous current of outside air is constantly drawn through the air holes. The roof of the air space formed by the hollow brick is pretty hot, but the bottom formed by the concrete has a temperature of about 250 deg., as measured by a pyrometer at various points. This temperature is not high enough to cause any damage to the concrete.

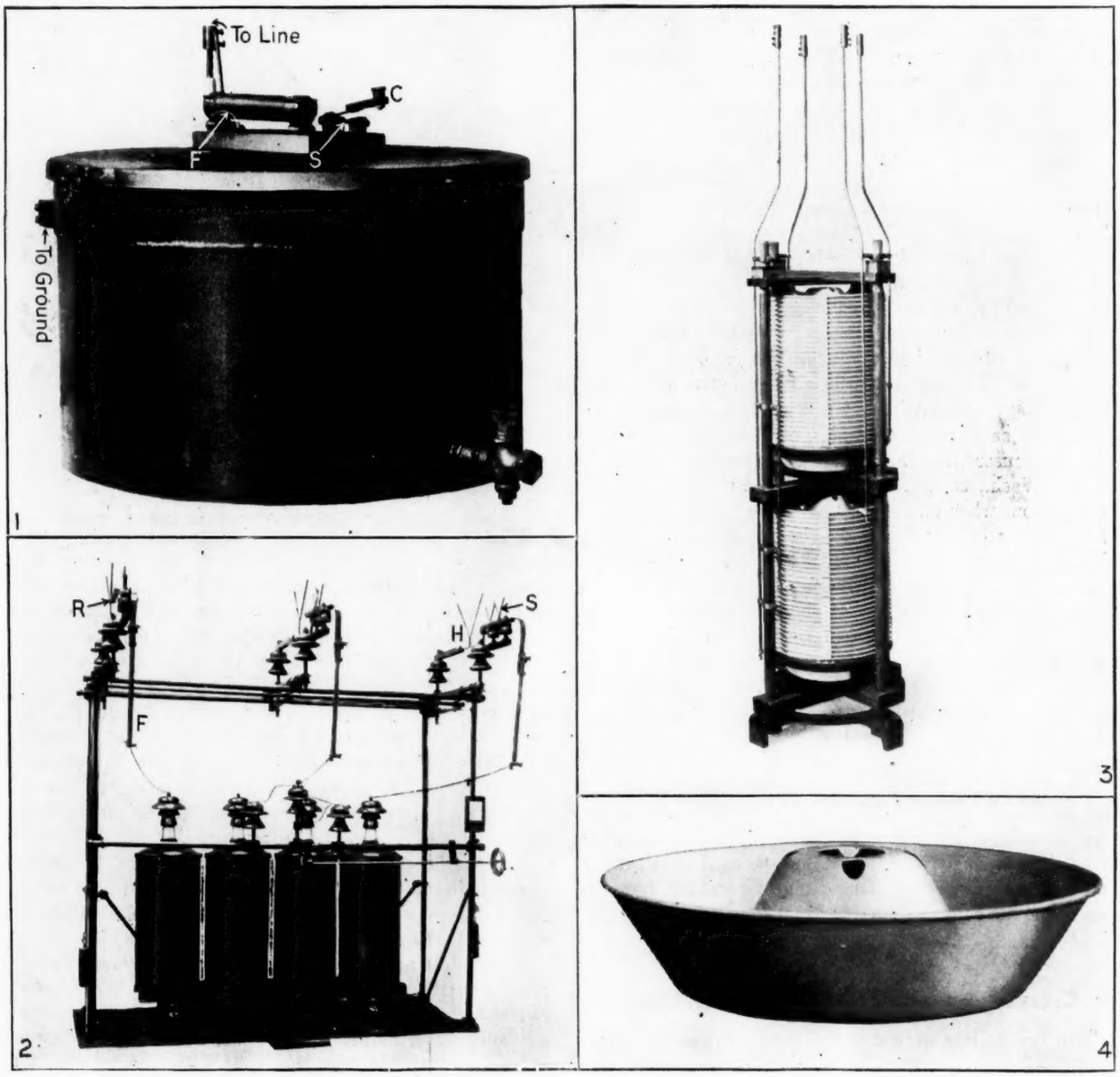
New Pipe Lines connecting with an engine should be blown out, the steam being allowed to flow into the steam chest, the ports of which have been either plugged or covered by the valve. This also applies to pipe-line repairs.

Improved Forms of Electrolytic Lightning Arresters

SYNOPSIS—Two improved types of electrolytic lightning arresters are described, one type designed for direct-current and low-voltage alternating-current circuits, the other for high-voltage alternating-current circuits.

The Westinghouse Electric and Manufacturing Co. of East Pittsburgh, Penn., has made several improvements in its line of electrolytic lightning arresters and now offers the two forms illustrated, designated as types A and AK. The type A arrester, Fig. 1, is designed for voltages up to 2,450 and is furnished for indoor mounting only; the type AK, Fig. 2, is for operation on alternating current at 2,000 volts and above.

The electrolytic lightning arrester offers a very high resistance to the flow of current at normal voltages and very low resistance to current at abnormal voltages, the change in resistance being instantaneous with the change in voltage. It also acts as a condenser, so that its effective resistance to current at low or normal frequencies is great; but on currents at high or abnormal frequencies such as the frequencies of static disturbances, it is small. These two properties are due to films electrochemically deposited on aluminum trays in the arrester.



FIGS. 1 TO 4. SHOW PARTS AND ASSEMBLY OF ELECTROLYTIC LIGHTNING ARRESTERS

While designed for direct-current service in railway or lighting power houses and substations, the present form of type A arrester, Fig. 1, with spark gap may be used for low-voltage alternating-current installations. It is similar in construction to the type AK except that no

charging resistance is required. The same aluminum trays are used, and these are mounted in an iron tank of ample strength, and of such size as to provide sufficient oil for cooling purposes under all possible operating conditions. As the size of aluminum plate exposed to the electrolyte is twice that of any other alternating-current aluminum arrester, this arrester exceeds in discharge capacity any other arrester for similar service. It is not limited to any particular kilowatt capacity of circuit. It is furnished with a fuse *F* mounted on top of the tank and with a spark gap *S* for insulating the arrester from the line. This gap can easily be short-circuited with the switch *C* for charging purposes, which operation should be performed once a day. The arrester can be operated on direct current with the spark gap closed, but in this case the leakage current disintegrates the aluminum trays and the electrolyte, giving them a much shorter life than when a gap is used.

The type AK arrester consists of a system of nested, aluminum, double cone- or cup-shaped trays, Fig. 3, supported on porcelain and secured in frames of treated wood, arranged in a steel tank. The system of trays is electrically connected between line and ground and between line and line. These trays contain a liquid electrolyte which forms a film on their surfaces. This film prevents flow of current to ground at normal voltages but forms a free path for abnormal voltages or static discharges. The distinctive features about this arrester are: A new inorganic electrolyte that is more stable chemically, less affected by heat, and which causes less dissolution of the film between charging periods than any other electrolyte previously used; double cone-shaped aluminum trays, Fig. 4, the area exposed to electrolyte being double that of any other arrester; trays spaced by porcelain pieces and not touching wood; ventilating duct in center of tray stack for additional circulation of oil; tank linings of Bakelite Micarta, impervious to moisture; charge and discharge resistance on all arresters, and fuses included.

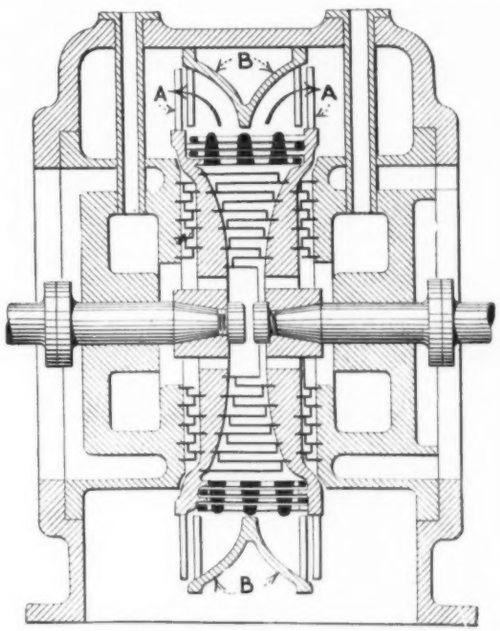
Type AK arresters for outdoor service are the same as the indoor arresters except that the former are provided with outdoor terminals. The outdoor arresters are not furnished for voltages of less than 10,000. For voltages below this the horn gaps cannot with safety be set close enough together out of doors to take advantage of the freedom of discharge of the electrolytic element. If the horn gaps are set too close they are short-circuited by rain.

A horn gap *H* is furnished on all type AK arresters, Fig. 2. They are readily adjusted for any line voltage and so arranged that the bridging necessary for charging is easily accomplished. On indoor arresters, for voltages below 9,900, bridging is accomplished by tilting one horn of each pair until a phosphor-bronze strip attached to each movable horn comes in contact with the corresponding horn and short-circuits the gap. A spring insures the return of the movable horns to their normal position after charging. For charging arresters on circuits of 10,000 volts and higher, the proper adjustment of the gap is obtained by setting a stop on the horizontal bar that turns one of each pair of horns about on its own axis. When properly adjusted for operation the horns are slightly offset. When the arresters are to be charged the horns are swung back until they are in the same plane. The horns when opened to their widest extent serve as a disconnecting switch and insure safety to those working about the arrester.

A charge and discharge resistance *R* is connected between the main horn gap and the arrester proper on all type AK arresters. The resistance units consist of rod resistors in shunt with small spark gaps *S*. The resistor is of a composition known as "Koppat," possessing the quality of remaining practically uniform under all conditions of service. The shunt gaps are between small horns. In the low-voltage arresters one resistance rod and one shunt gap are used. In the higher-voltage arresters, two of each are used in series. The charge and discharge fuses are shown at *F*.

Axial Two-Way Exhaust for Ljungstrom Turbine

A recent patent describes the addition of radial blades to a Ljungström turbine, as shown at *AA* in the accompanying sketch. The guide piece *BB* splits the disk of steam issuing radially from the regular Ljungström blade system and turns it to either side, causing it to pass axially through the blade system *A*. In the sketch, only one row of stationary guide blades on either side and one



SECTION SHOWING RADIAL BLADES

row of moving blades attached to either rim of the revolving element are shown, although more could be used if desirable. A full area is thus obtained for the final exit of the steam, permitting more complete expansion or, in other words, reducing the "leaving loss." The greater velocity of the blade allows a greater velocity of steam flow with the same efficiency, which conduces to the same end. The radial disposition of the blades reduces to a minimum the difficulties due to centrifugal force.

Advantages of Small, High-Velocity Steam Piping are: Lower first cost for pipe, valves and covering, etc.; less erecting and maintenance cost; less weight; less radiation loss; less chance for water to accumulate; and less difficulty with valves of smaller size.

Indicating the Ammonia Compressor--VI*

By Robert H. Karl†

SYNOPSIS—Last of a series of six profusely illustrated articles on indicating ammonia compressors. This article tells how to apply the indicator and what precautions to take to avoid certain troubles and inaccuracies.

Most ammonia compressors leave the shop with holes drilled and tapped for applying an indicator, generally in the side of the cylinder. Into the hole so prepared screw the indicator cock directly whenever possible. If it is necessary to use any pipe so as to clear any obstruction to get a straight line to the crosshead, use double-extra-heavy pipe. This has a smaller internal area than the ordinary ½-in. pipe. The reason for using as small a bore as possible is to reduce the clearance.

For indicating compressors, the arrangement, Fig. 36, should not be used either in a horizontal or a vertical compressor cylinder. It cannot be depended upon for accuracy, as it produces distortions by wiredrawing and clearance. Fig. 37 is still worse, where angle valves are used at the ends of the cylinders and connected with side pipes in the center of which is a tee for the indicator cock. This arrangement causes still more clearance space than

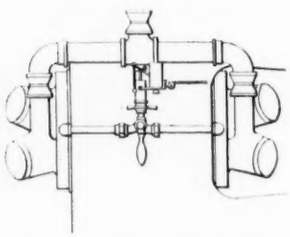


FIG. 36. COMMON INDICATOR CONNECTIONS

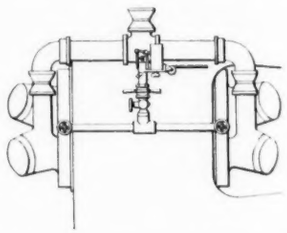


FIG. 37. AUTHOR DOES NOT APPROVE ANGLE VALVES

that shown in Fig. 36, and besides, the angle valves might leak. The foregoing applies also to the vertical type of ammonia compressor.

In putting up piping or connections for use with the indicator, use no red lead, litharge or other mixture, as it is likely to cause trouble. Good sharp, clean-cut threads with a little oil are usually all that is required. Fig. 38 shows the result of indicator connections made up with litharge in a short pipe connection between the stationary indicator cock and compressor cylinder. When the pipe was screwed tight, the litharge was forced ahead in a loose lump and hardened, and when the indicator was applied this lump of litharge acted as a check valve, producing the diagram shown.

Every possible precaution should be taken to remove from the indicator connections all scale, dirt, etc., that would be liable to get into the indicator cylinder. Blow all pipe and connections thoroughly before attaching the indicator; a little particle of dirt can do a great deal of damage to the cylinder. Besides, dirt will also cause some freak diagrams, such as shown in Fig. 39, taken from a compressor that had an accumulation of dirt in the indicator-pipe connections. After this pipe was thoroughly cleaned, a good diagram was taken.

Before and after using the indicator, clean it thoroughly and oil it carefully. The indicator is like the engine, only more delicate and sensitive, and if one expects it to

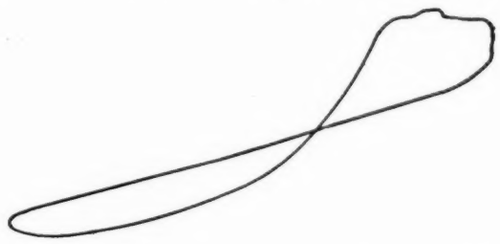


FIG. 38. INDICATOR PIPE PLUGGED WITH LITHARGE

work freely and smoothly, it must be carefully cared for. Be sure there is no lost motion. This is particularly to be guarded against in indicators, and few are free from this defect. Freedom from friction is important.

The springs are the vital part of the indicator, and the value of all work depends upon their correctness. Be careful to select the spring with the proper tension adapted to the pressures and speeds that will be encountered. By using springs that are too weak or too strong, a distorted diagram will result. This effect is particularly noticeable in ammonia-compressor diagrams, because, as pointed out in another article of this series, there are many factors that influence the diagrams and often make them misleading, and by using springs unsuitable for the pressures, you are multiplying the distortions that are likely to be encountered.

Fig. 40 shows the effects of too stiff a spring. The condenser pressure on the gage was 176 lb., and the gage was correct. The spring used was 150 lb. As scaled on the diagram, the condenser pressure is only 143 lb., or a difference of 33 lb. Then, besides, this stiff spring gives

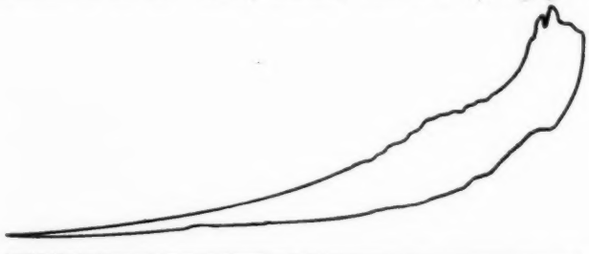


FIG. 39. LOOSE DIRT IN THE INDICATOR PIPE

a diagram that is much too small, and it is not possible to reveal defects that might exist or to make a proper analysis of the diagram. A spring that is too weak for the pressure or speed encountered will distort the diagram. Different types of indicators will cause distortions in different ways, owing to the use of springs that are too stiff or too weak for the pressures and speed.

*The other articles of this series appeared in "Power" for Apr. 25, May 16, June 27, July 25 and Aug. 22.

†Engineering department, Anheuser-Busch Brewing Association, St. Louis, Mo.

The error in the final results will be less if the diagram has a large area, and the smaller the area of the diagram the larger will be the error in the final results.

Another important item in taking diagrams is the pencil point. Do not use soft lead; it makes too wide a line

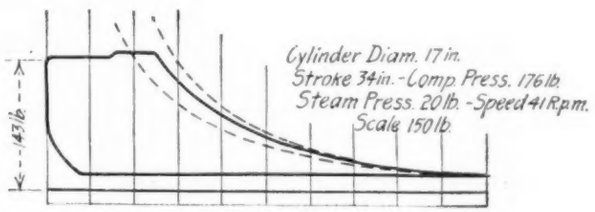


FIG. 40. SPRING TOO STIFF

and is not clear—it is more or less blurred. Use a hard lead with a sharp point. If you use metallic points, keep them sharp-pointed. The pencil should trace a fine, clear, distinct line. When you take diagrams, the greatest care should be used in not pressing the pencil point too hard on the paper. There are more poor diagrams from this cause than from any other.

Use for the reducing motion cord that will not stretch, and if it is necessary to use cord carrying pulleys to clear any obstructions, make all turns or bends right angles or square and have the cord connection to the crosshead in a straight level line; that is, allow up or down no pitch of the cord. Be careful that the drum travel and reducing motion are correct for the stroke of the compressor. These precautions are all necessary if you wish to obtain diagrams that are correct.

An indicator built entirely of steel or aluminum is preferred for ammonia work. However, if your indicator is of brass or bronze composition, it can be used without danger of damaging the instrument if it is thoroughly cleaned and oiled afterward.

Visits of Inspector Brown--XVI

By J. E. Terman

SYNOPSIS—Brown has his attention called to the A. S. M. E. boiler-code rules by Casey, the boiler manufacturer. The section regarding safety valves is attacked, and Brown seeks information as to the method of figuring the area of safety valves.

Brown came into the office, threw his grip under a table and was wiping the perspiration from his forehead when he noticed, through the glass partition, that the Chief was beckoning him to come into his office. When Brown reached the desk, the Chief gave him a hearty handshake and asked where he had been all summer. "If I hadn't been receiving your reports regularly, I would have thought that you had enlisted."

"Well, Chief, do you know, I think that my life would be in less danger in the trenches than it is in this business. You know you told me some time last year that I had better study up on the new code of boiler rules put out by the American Society of Mechanical Engineers, and that I should advise the use of the Code rules in connection with new construction whenever I found an opportunity to do so. Well, I tried to live up to those instructions to the best of my ability; but unless you can help me out, I am afraid that the foreman at Casey's shop is going to get the best of me and prove that the safety-valve requirements in the Code are away off."

"Why, Brown, that must be impossible. If my memory serves me correctly, it was understood that all the different interests were consulted when the Code rules were written; and if that was so, the safety-valve manufacturers must have had a hand in getting up the Code.

"That's just what Casey's foreman contends," said Brown. "He says that the safety-valve rules must have been written entirely by the valve manufacturers during a period of poor business, when they had nothing to think of but how their business might be improved, and that they made the rules accordingly."

"Well, that was a nasty insinuation on the part of Casey's foreman," said the Chief, "and I hope you did not fail to give him a call."

"I did, to the best of my ability. I told him that because he was always trying to put one over on the inspector, he thought that everybody else in the boiler game was up to the same tricks. But the trouble is that the foreman seems to be able to prove by figures that the Code requirements for safety valves are unreasonable as compared with any other set of rules now in existence.

"I will tell you," continued Brown, "just how this thing started. I find that Casey has bid on two boilers that were specified to be built to comply with the rules of Massachusetts, Ohio, Indiana, Wisconsin, Pennsylvania, California, Detroit, Philadelphia and Memphis, Tenn. Anyone but Casey would have investigated this matter before making a bid on the job, but you know Casey does not believe in crossing any bridges until he is right up on them; so he made his bid on the basis of a Massachusetts boiler, for he explained to me confidentially that he reasoned that the Massachusetts rules would give him as much trouble as any of the others and that he would be safe on that basis.

"When Casey heard that I was in the shop to inspect the repairs that have been made to that little locomotive boiler for the Crown Milling Co., he sent word for me to come into the office before I left and to bring the foreman with me. When we reached the office we found Casey in a stew. He had just that morning received word that his bid had been accepted, and he had really started to study the specifications. He had on his desk all the rules he possessed in regard to the different boiler laws, and I could see that he was terribly disturbed as to how he could fill this order. He asked that I help him out, and it certainly gave him a lot of relief when I told him that the Ohio, Indiana, Wisconsin, Pennsylvania, California and Detroit requirements would be met by sticking to the A. S. M. E. Code rules and that the Massachusetts rules would answer for Memphis as well as for Massachusetts.

"Casey was so happy, Chief, that he gave me a slap on the back and called me 'friend Brown,' and I really believe that he would have forgiven me for turning down that boiler for Ohio last month if the foreman hadn't piped up with, 'how about the safety valves?'

"'Well,' says Casey, 'how about them?'

"'Nothing,' says the foreman, 'but you had better put your order in right away, for you know it is hard to get deliveries now and that is going to be a big order if the Code rules have to be met.'

"'What the h—l do you know about Code rules?' asked Casey.

"'Nothing,' says the foreman, 'but Mike Doherty, over at Henderson's, told me that they built a couple of boilers to Code rules last month and that when they put the safety valves of the first boiler to mark the bases for drilling, all the boys in the shop never stopped cussing until they took the valves off, because the boiler had so many on it that it looked like a pipe organ, and the boys couldn't get it out of their heads that they were not in church.'"

"Now, Brown," said the Chief, "suppose we look into some of these safety-valve rules and see how they compare. Of course, the purpose of a safety valve is to discharge steam when the pressure tends to rise, and to prevent an excessive pressure by carrying off the steam as fast as it is generated; therefore, any logical safety-valve rule must be based on the discharge capacity of such valves. A simple rule to determine the weight of steam in pounds discharged from an orifice is Napier's approximate rule, and practically all safety-valve formulas are based on it, which is, 'The weight of steam discharged from an orifice in pounds per second equals the absolute pressure times the area of the orifice in square inches, divided by 70.' Expressing this as a formula, so that you will be able to remember it easily," continued the Chief, "let

"W = Weight of steam in pounds per second;

"A = Area of the orifice in square inches;

"P = Absolute pressure in pounds per square inch.

"Then the formula to determine the number of pounds of steam discharged per second would be $W = A\frac{P}{70}$. Now, you must remember, that W is the weight of steam in pounds per second, for that is where most of the fellows fall down on this problem. You, of course, know that the absolute pressure is that measured above a vacuum—that is, 14.7 lb. more than the gage pressure."

"Well, that is certainly a simple formula, Chief. The one in the Code is about as long as your arm, and I suppose that is the reason that it calls for so many valves."

"Hold on, Brown," said the Chief; "don't begin to criticize until you know what the Code formula means. You will notice in the Code that the table giving the discharge capacities for safety valves with beveled seats, where the bevel is 45 deg., is divided up into sections for each 25 lb. increase in pressure and that the last line in each of these sections gives the amount of steam in pounds per hour discharged by a valve of the size mentioned at the top of the column, for the different lifts given. The reason that the discharge is given in pounds per hour instead of per second is because boiler capacities are generally indicated in pounds of water evaporated per hour. The Code table has a 4-in. diameter bevel-seated valve with a maximum lift of 0.12 in., marked to deliver 7,354 lb. of steam at 125 lb. gage pressure. Now, Brown, let's see if you can tell by the use of Napier's rule how much steam a 4-in. valve should discharge. Work it out here," said the Chief, handing Brown a pad.

After a time Brown handed the Chief a sheet of paper containing the following figures:

$$W = 0.7854 \times 4^2 \times \tfrac{125}{70} \times 3{,}600 = 80{,}784 \text{ lb.}$$

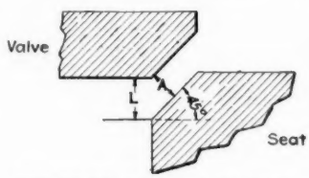
"You see, Chief," said Brown, "Napier's rule gives over ten times the amount of steam discharged that the Code gives in the table of discharge capacities."

"Your figures certainly do show some discharge capacity for a 4-in. safety valve; just explain how you get that result, Brown."

"Well, the area of a 4-in. valve is 0.7854 times the square of the diameter, and you said that the pressure was 125 lb. Since the formula gives the steam discharged in one second of time, I multiplied by 3,600 to get the steam discharged in an hour's time, because there are 60 sec. in a minute and 60 min. in an hour. Therefore, there would be $60 \times 60 = 3{,}600$ sec. in an hour."

"Well, Brown, you did not get mixed up on that time element, any way, but I must tell you that you have not applied Napier's rule correctly. You have worked out the area of a 4-in. circle all right, but you certainly do not mean to tell me that you believe that a 4-in. valve that is lifted 0.12 in. from its seat would have a discharge area as large as the area of a 4-in. circle, do you?"

"Of course not, Chief. I know that a valve must lift one-fourth of its diameter above the seat before the discharge area will equal the nominal area. I don't know why I was so thick. I should have taken the circumference of the valve and multiplied it by the lift, and the result would have been the area of the discharge opening," said Brown, starting to perform the operations.



BEVELED SAFETY VALVE AND SEAT

"Hold on, Brown," said the Chief; "you are not quite right about that yet. See if you cannot think of another error that would be made by calculating the discharge area in that way."

After considerable thought Brown admitted that he would have to give it up, for he could not see why the method he proposed would fail to give the correct discharge area.

"Well," said the Chief, "maybe a sketch might help you to see the difficulty." (See illustration.) "Now can you see anything that would make your method for getting the discharge area incorrect?"

"Sure," answered Brown, "I never thought about the effect the bevel of the seat might have on the discharge area when the valve was lifted only a small amount, but I see now that the discharge area would not be the circumference of the seat times the lift, but that the opening between the valve and the seat would be A, while the lift of the valve would be L. Since you say that the angle of the level is to be 45 deg., the lift would be the hypotenuse of a right-angled triangle with two sides each equal to A; and since the square of the hypotenuse equals the sum of the squares of the other two sides, A would be the square root of one half the square of L, or the effective lift would be $\sqrt{\frac{L^2}{2}}$ and the formula for getting the discharge by Napier's rule," continued Brown, "would be

$$W = 3.1416 \times 4 \times \sqrt{\frac{(0.12)^2}{2}} \times \frac{125}{70} \times 3{,}600 \text{ lb.}$$

"How does that strike you, Chief?"

"I should let you work it out and find your mistake," said the Chief, "for there is nothing else that tends to impress mistakes on a fellow so well as to work out a lot of figures and then find that he has made an error."

"Why, I don't see how it is possible that I have made another mistake!"

"But you have, Brown, and it is the fraction in your formula. You should have remembered that it was absolute pressure that we were to deal with, so instead of the numerator of the fraction being 125 it should have been 125 + 14.7, or 139.7, and the formula would become,

$$W = 3.1416 \times 4 \times \sqrt{\frac{(0.12)^2}{2}} \times \frac{139.7}{70} \times 3{,}600 \text{ } lb.,$$

$$\text{or } W = 7{,}662 \text{ } lb. \text{ } per \text{ } hr.$$

which is different from the 80,000 lb. you had at first."

"Yes, Chief," answered Brown, "but I notice that it is not the same figure that the Code gives, 7,354 lb.

"No, but if you will multiply 7,662 by 0.96, you will get 7355.5, which I think you will admit is checking up very close. The Code formula uses 0.96 as a safety factor, so that the formula will certainly not give a higher rate of discharge than a valve would actually show under operating conditions. The formula in the Code for the discharge of steam in pounds per hour would be

$$W = 3.1416 \times D \times L \times 0.707 \times \frac{P}{70} \times 3{,}600 \times 0.96$$

where D is the nominal diameter of the valve, L is the lift, both in inches, and P and W are as before taken. By substituting 4 for D, 139.7 for P and 0.12 for L the result would be 7,355.5 lb. per hr., as was found before."

"Hold on, Chief; I don't follow you," said Brown. "It seems that you have replaced the quantity that I had under the radical sign by $L \times 0.707$ in the formula you have written as indicating the Code results."

"Gee, Brown!" exclaimed the Chief. "It is 6:30 and I promised to give a talk to the engineers tonight. You will have to try to figure that out for yourself. Come in tomorrow afternoon and we will continue this comparison of safety-valve rules, which is quite a subject."

Cameron Centrifugal Pump

The development of the steam turbine and the high-efficiency multistage centrifugal pump have gone hand in hand, but it has been difficult to reconcile the speeds of the two machines so that each would work at its best efficiency.

It was necessary, heretofore, to reduce the speed of the turbine and sacrifice much of its efficiency or else speed up the pump with similar results. To overcome this difficulty the Cameron Steam Pump Works has designed and built a multistage centrifugal pump, known as the BT type.

Fig. 1 shows the construction of one of these three-stage pumps. The high-speed feature is a virtue of impeller design. Small external diameter and adequate vane length are obtained by bringing the vanes well down into the impeller hub and so turning them that the incoming water is guided smoothly and with little loss into the outer portion of the vanes, where the velocity is generated that is finally converted into useful pressure by means of the external diffusion vane.

Both the suction and the discharge connections are in the lower half of the casing that is divided along the horizontal center line. The upper half is removable, giving full access to the revolving element. There are suitable openings for draining the pump and for displacing the air when starting. Inlet and outlet nozzles can be arranged either on the same or on opposite sides.

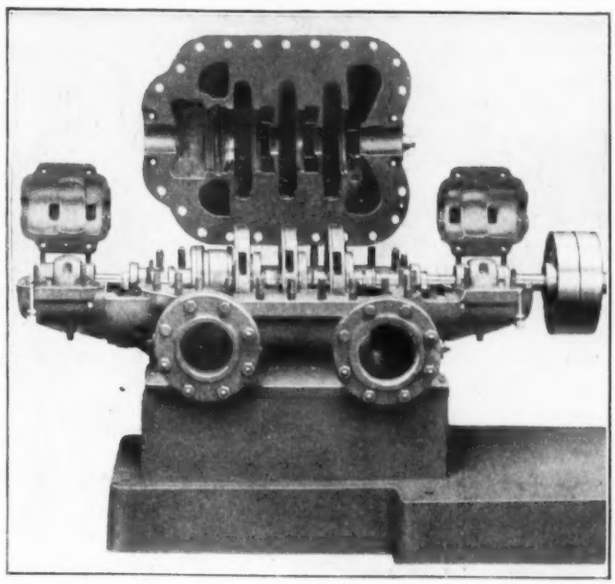


FIG. 1. THREE-STAGE PUMP WITH COVER LIFTED

Wherever the steel shaft comes in contact with the fluid being pumped, it is protected by bronze sleeves, which prevent the stuffing-box packing from scoring the surface of the shaft.

Each impeller is cast solid in one piece and is of the inclosed type. Surrounding each impeller hub is a pair of rings—one stationary, attached to the casing, and one revolving, attached to the impeller. By the use of double rings it is possible to restore the initial tightness of the joint between the low- and high-pressure sides of each stage without any fitting.

The diffusion ring surrounds the impeller at its periphery, although it is not in contact with it. It contains a series of openings, which receive the water from the impellers at high velocity and by means of gradually increasing area toward the periphery reduce the velocity into pressure and enable it to advance to the entrance to the next impeller with much less loss of energy than would be the case if the high velocity of ejection were maintained.

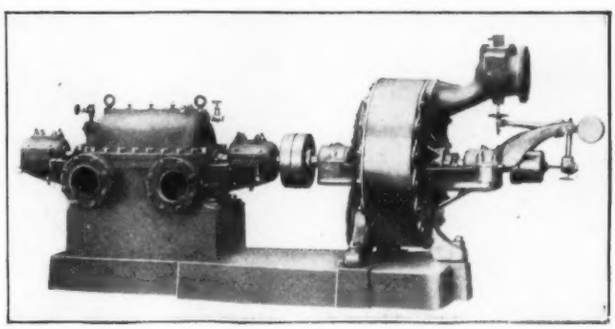


FIG. 2. PUMP AND TURBINE

To take care of thrust this pump is equipped with a simple internal hydraulic balancing device. This consists of a revolving disk attached to the shaft at the inboard or high-pressure end. Opposite this disk is a stationary drum of the same diameter. Water at high pressure connects with the space between the disk and the drum, causing the disk to react against the opposing thrust, neutralizing it and holding the rotor in proper relation to the casing. The slight leakage involved in this process is piped back to the suction.

The stuffing-boxes are deep and are provided with water seals consisting of a lantern gland in each box, connected to the water from the discharge side of the pump, through a concealed passage so arranged that it can be readily cleaned. The stuffing-box gland is fitted with swing bolts to give quick and easy access to the stuffing-box.

The bedplate under the pump is of one piece box construction heavy enough to give a rigid support, and with cross-ribs to prevent distortion.

Fig. 2 shows this pump assembled.

Idlers on Vertical Belts

By Lewis F. Lyne

Belts running in a vertical position, or nearly so, are generally pulled up very much tighter than is actually required to transmit the power, the extra friction resulting in overheating, etc. The weight of the 14-in. belt, Fig. 1, caused it to fall away from the lower pulley. A piece

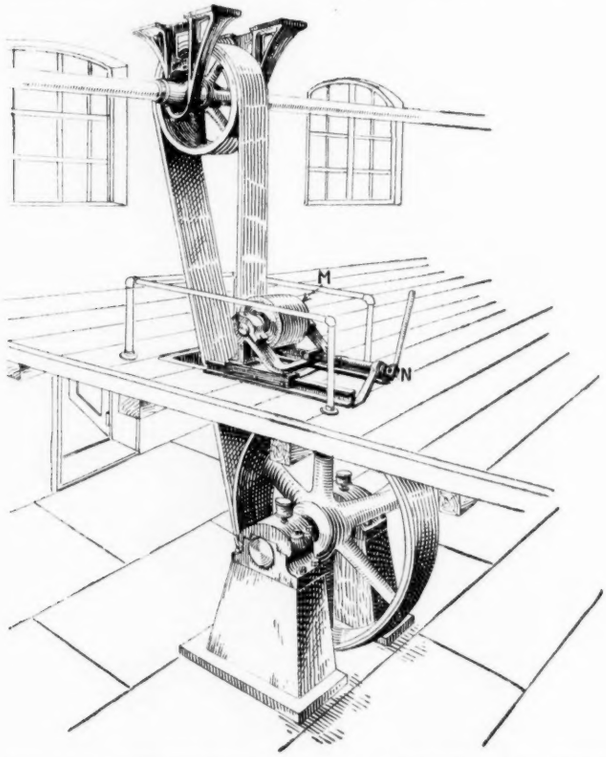


FIG. 1. APPLICATION OF TIGHTENER TO VERTICAL BELT

about 3 ft. long was inserted and the belt made endless, using a tightener pulley *M* 16 in. diameter tightened with screw *N* so that the slack side of the belt was within about 8 in. of the tension side. By this arrangement the operator can secure any desired tension upon the belt and allow for stretch in damp weather and shrinkage in dry weather. With belts that run in the opposite direction or in cases where one shaft is directly over the other the trouble with belts sagging away from the lower pulley becomes greater, but the application of an idler on the slack side meets all requirements.

Some years ago the writer was asked to advise in connection with vertical belts that transmitted power from the jackshaft in the basement to the various floors in a factory (Fig. 2), in which the vertical distances between

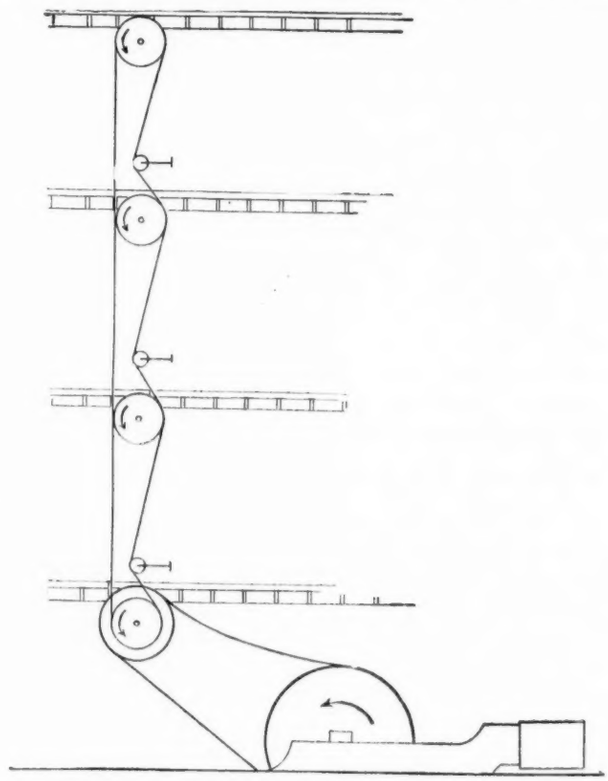


FIG. 2. NOT AN UNUSUAL FACTORY PROBLEM

centers were from 12 ft. to 14 ft., and the transmitting pulleys were placed side by side, as shown. These belts were all of the best leather, but in dry weather they were always too tight, while in damp weather they were too slack and slipped. A compound of a sticky composition was resorted to, which afforded only a partial relief.

Upon each floor 24-in. idler pulleys were installed as shown, so as to leave about 18 in. space between the two sides of the belt, and adjusted by the usual screws. By this means any desired tension was secured, and excessive tensions were entirely done away with. Before these changes were made, it was a common thing for bearings to require rebabbitting and the waste of oil was enormous, but afterward the bearings ran cool with a moderate supply of oil.

When Speaking of the Center of an Object, it is well to define what is meant, as there are three different centers to a body—the center of magnitude, the center of gravity and the center of motion. These may or may not coincide in a given body. The center of magnitude of a body is the central point of its bulk; the center of gravity is the point about which all the parts balance one another; the center of motion is the point around which all the parts of a body move. When the body is of a size or shape so as to allow every point to revolve in the same plane, the line around which it revolves is called the axis of motion. The center, or the axis of motion, is generally supposed to be at rest.

Swedish State Hydro-Electric Power Station

According to *London Engineering,* the great hydro-electric power station at Alfkarleby, the third of the large Swedish state hydro-electric enterprises, has been completed and has begun the distribution of electric energy. The exploitation of the Alfkarleby Falls on a large scale was first considered in 1893, but it was not until 1910 that the Royal Waterfalls Board, which had in the meantime been constituted, completed the plans which the following year were passed by the Riksdag, and a grant of $2,483,700 was voted to carry on the work. To provide for distributing the power the sum of $1,704,500 has so far been placed at the disposal of the Waterfalls Board.

The power plant contains five horizontal fourfold Francis turbines (four water wheels on the one shaft) with movable cast steel guide blades, which are connected direct to the generators. Each turbine develops normally 11,250 hp. at 150 r.p.m. working under a 51-ft. head and is guaranteed to have an efficiency of 85.5 per cent.

Electrical Equipment and Control

The generators are 50-cycle machines generating three-phase current at 10,000 volts and are guaranteed to carry a continuous load of 12,250 kv.-a. at 0.75 power factor, which corresponds to a maximum output of the turbines of 13,000 hp. From the generators the current is transmitted to the switchhouse about 400 ft. away from the main station, where it is stepped up through transformers. Operation and control of the entire electric installation is done from the switchhouse.

Each generator is normally excited by a direct-connected exciter. The voltage of the alternator is regulated by hand-operated rheostats in the exciter field. In addition to the exciter, there is in the station a 220-volt lighting installation, which comprises two motor-generator sets, each consisting of a synchronous motor driving a 150-kw. 220-volt direct-current generator. In addition to the motor-generator sets a 1,500-ampere-hour battery is used. The lighting installation can be used for excitation in case one of the regular exciters fails. A special series rheostat is provided, through which the alternators may be short-circuited to bring them to rest.

The transformer installation comprises 3 three-phase 1,500-kv.-a. transformers for stepping up from 10,000 volts to 20,000 volts connected delta on the primary and star on the secondary, for power distribution in the local district around the power station, and four transformer groups each consisting of three single-phase 4,800-kv.-a. transformers for long-distance distribution. Of these latter transformer groups, one is arranged to step up from 10,000 volts to 40,000 volts, with both primary and secondary connected delta, and two other groups for stepping up from 10,000 volts to 70,000 volts with primary connected delta and secondary star. The fourth transformer group is arranged so that it can be connected delta on the secondary for transforming from 10,000 volts to 40,000 volts, or star on the secondary for 70,000 volts.

If the three 20,000-volt transformers are looked upon as one group, it will appear that the power station thus comprises an aggregate of five transformer groups, of which one is 13,500 kv.-a. and four of a maximum of 14,400 kv.-a., which correspond to a transformer group of 15 to 20 per cent. higher output than the generators can yield at a maximum. This margin in capacity of transformers is provided because it has not been possible to foresee accurately how the power consumption will be divided between the different systems. The transformers are water-cooled, oil-insulated and fitted with safety valves, maximum alarm thermometers and distance thermometers, besides an alarm for notifying interruptions of the cooling-water circulation. Each transformer can, mechanically, stand short-circuiting on the high-voltage side with all the five generators of the station coupled in parallel.

It is proposed to adopt electric heating of the ice guards in the turbine chambers. For this purpose there will be installed transformers that can be attached to the 10,000-volt bus and step the current down to the low voltage necessary for the heating.

The neutral on each of the three-phase generators and of the transformers is grounded through a resistance. The 40,000-volt system is grounded through a three-phase voltage transformer, with its neutral point directly grounded on the high-voltage side.

So far neither choke coils nor excess voltage protective apparatus other than the grounding resistances have been installed. Although the power station has been working for several months, no fault whatever has manifested itself in any portion of the high-voltage installation, so that excessive-voltage protection beyond grounding resistances and ground lines has not been found necessary.

The design and construction of the Alfkarleby power station has been carried on under the auspices of the Royal Waterfalls Board, through its chairman, Col. F. B. Hansen, aided by a numerous staff of engineers.

Daum Refillable Fuse Shells

The Daum refillable cartridge fuse shells for lighting and power circuits are made in various forms. The thread-end washer type (Fig. 1) consists of a cartridge threaded for end caps. A washer fits between the ends of

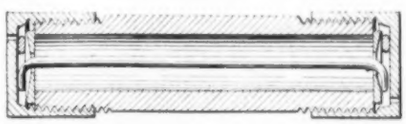


FIG. 1. THREADED WASHER FUSE SHELL

the cartridge and the inside surface of the cap. The fuse strip is passed through a hole in the washer, and the ends of the fuse are bent over so as to be compressed between the washer and the end caps when the latter are screwed up tight.

Fig. 2 shows the latest, a knife-blade fuse. The copper end blades are cast into the cap. These ends fit into ter-

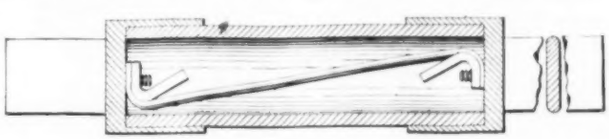


FIG. 2. KNIFEBLADE FUSE

minal contact pieces. The method of securing the fuse is shown. These and other fuses are made by A. F. Daum, Pittsburgh, Penn.

Venturi Meters Inaccurate on Lively Lines*

By Allen Hazen†

When there is a steady, uniform flow through a venturi meter, the coefficient of discharge—that is, the ratio which the actual quantity of water bears to the theoretical quantity—is very high and for practical purposes may be taken as 0.99, with a small variation either way. But venturi meters are often used on pipe lines where the flow is not uniform. If the variations are gradual from hour to hour, or even from minute to minute, the apparatus that is ordinarily used will sum up the total flow with accuracy. If, however, the variations in flow are rapid, so that there are substantial changes in rate in a single second, an error may be introduced. This error may be one of considerable importance on lines carrying water directly discharged from reciprocating pumps or from a reservoir into a system where wide and sudden fluctuations in rate of draft are taking place.

A number of circumstances tend to increase this fluctuation. Among them may be mentioned a relatively short discharge line, air chambers that are too small or not adequately connected with the pipes and a high degree of elasticity in the material of the pipe. Steel pipes are more elastic than iron pipes, and there is apt to be more jump or vibration with changes in rate through them. A lively line, for which considerable errors may be anticipated, may be defined as one on which a pressure gage connected to the line wide open will show considerable and rapid fluctuations.

The theoretical reason for the error is that the venturi recorders in reality sum up the squares of the flows. In other words, the flow is averaged by squares instead of directly. The height of the mercury column that is the starting point in the registration is proportional to the square of the velocity.

To take an extreme case, suppose that for half a second the velocity is nothing and for half a second it is 2 ft. per sec. For the whole second the average velocity will be 1 ft. per sec.; but the height of the mercury columns will tend to be for the first phase 0 and for the result corresponding to the average height of the mercury column, which is 2, and the quantity indicated will be the square root of 2, or 1.41, in place of the true quantity, which is 1. In this case the error of over-registration will be 41 per cent.

This merely illustrates the way in which the error is produced. An actual error as large as 41 per cent. is not to be anticipated in any case. However, with very lively lines errors of 2, 5 or even 10 per cent. or more may be anticipated, depending upon the liveliness of the line. The error will always be in the same direction—namely, the registration will be above the truth.

So far as the writer's experience goes, the percentage error with lively lines is very much greater at low flows than at higher flows; the source of error was first brought to his attention in using the venturi meter as a means of checking up the minimum rates of flow into a completely metered system in the early morning hours, when there would normally be little use. The meter was found to over-register for these conditions as compared with the strokes of a pump to an extent that could not be accounted for, although the meter was known to register with approximate accuracy for the higher rates.

It may be pointed out that the errors in the venturi measurements resulting from rapid fluctuation in velocity also occur with the pitometer or standard orifice or any other method of measuring water which depends upon the effect of velocities upon pressures. These studies indicate the need of some new and better apparatus for integrating flows of venturi meters and pitometers.

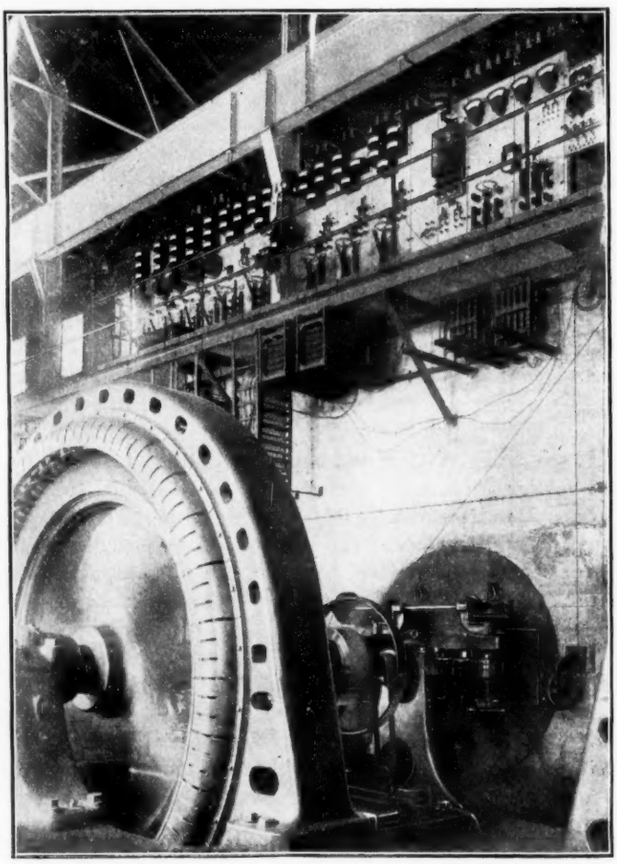
*From "Engineering News."

†Of Hazen, Whipple & Fuller, Consulting Engineers, 30 East 42nd St., New York City.

Installing Field Rheostats

By H. S. Knowlton

To locate field rheostats out of harm's way, and in a position where good ventilation may be secured, is sometimes a problem in the modern power plant. The Deer Rips station of the Androscoggin Electric Co., near Lewiston, Maine, solved this problem by mounting the rheostats on the under side of the switchboard gallery, as shown in the accompanying illustration. Angle irons and channel



RHEOSTAT UNDER SWITCHBOARD GALLERY

irons form a framework for the various sizes of rheostats, the channels being bolted to the outer edge of the gallery or held in place by nuts on the threaded ends of vertical tie-rods as shown. This location frees the equipment from the usual dangers of traveling-crane chains, provides ample clearance above the generating units, concentrates the control wiring and gives each resistance unit an excellent amount of air space in comparison with the frequent practice of locating rheostats in framed structures on the operating floor or in poorly ventilated basements.

Editorials

Thirty-Fourth Annual Convention of the N. A. S. E.

Annual conventions put one in a reminiscent mood. If the first convention antedates the beginning of an epoch in the art, reminiscences become interesting indeed.

At Minneapolis, from September 11 to 16 inclusive, the National Association of Stationary Engineers will hold its thirty-fourth annual convention. Thirty-four years is not a long time in the history of human arts, but broadly, no other field of activity has undergone such remarkable development in that period as has engineering. Narrowing one's vision down to the power-plant field, it is indeed a pleasure to note what time has wrought in half of that threescore and ten years conventionally allotted to man. One immediately appreciates, in a rough way, what this development has been when he recollects that electrical men particularly have but finished celebrating the thirty-fifth anniversary of the invention of the incandescent lamp. Electric lighting and electric power gave the power-plant industry an impetus that carried it beyond many of the engineers operating at the time of their introduction.

The National Association of Stationary Engineers was born on the threshold of unprecedented development in the art. One must view it this way if he is to judge rightly of the association's progress and of how well it lives up to the ideals of its founders.

Thirty-two years before the organization of the association, George Corliss brought forth his valve gear and made other improvements on the steam engine which up to the time of Corliss was essentially the same as the immortal Watt had left it.

Engineers were, however, slow to adopt the Corliss engine; did, indeed, heap ridicule upon it and its inventor. To quote from *Power* of March, 1888, which contains the obituary of Corliss: "The engineering fraternity of the country treated the innovation of a 'country boy' with what they conceived to be a suitable contempt, and one of them ingeniously nicknamed the movement a 'come-and-go-fetch-it' motion. To the credit of the renowned engineer, Erastus W. Smith, it may be said that he was the first of his class to boldly adopt the Corliss engine, and he did not do so until 1853," four years after its invention. Its later universal adoption and supremacy are too well known to require discussion. The point is that it created an epoch in steam engineering which was later followed by the advent of electric machinery, whose influence on industry is surpassed only by the inventions of Watt and Newcomen.

The National Association of Stationary Engineers is a child of this epoch. At this, its thirty-fourth annual convention, it meets on what is likely the crest of the wave of steam-turbine development. Contemporaneous with the progress of this wonderful type of prime mover there has been remarkable development in boiler-room practice and in power-plant economics.

An era of refinement in the art is well on its way. It calls for a wider and far more thorough knowledge of the business by operating men than has heretofore been required. It is an era to sober one's judgment and make one visualize and prepare for the future.

Convention signifies a body of representatives met for some common purpose. By far the greater number of national conventions of the National Association of Stationary Engineers have had as their chief feature the election of the vice-president, an important matter of course, but those who have the interest of the organization at heart cannot but ask themselves if there are not constructive policies of far greater import that should receive the consideration of the delegates who are there to best serve the interests of the entire membership. The preamble says that "preference shall at all times be given to the education of the engineer." Is it? Is the admirable work of the educational committee all that it might be made to be if the convention could make the national membership more keenly realize the tread of the status of the operating engineer? We think not.

One does not need to argue the value of reading and discussing papers at conventions. The most successful organizations attribute the major part of their success to this very practice. Unfortunately, all too few papers are read at either national or state conventions of the National Association of Stationary Engineers. The defense that it is usually too hot for the presentation and discussion of papers is indeed childish. The convention is not called to further the interests of the weather. Is the heat any more intense or oppressive when listening to an interesting and valuable paper or discussion than when in the throes of parliamentary harangue?

We believe that the Minneapolis convention will be one of the best in the history of the organization. Associations and memories dating back to the days of its swaddling clothes give *Power* a more than friendly interest in the welfare of the National Association of Stationary Engineers.

American Water Pipe in Egypt

In pleasing contrast with the criticisms heard so frequently nowadays, of the inferior American methods of preparing or packing goods of all kinds for foreign shipment comes a frank, unqualified and what might almost be called an enthusiastic statement by Percy G. Donald, a large British buyer, in the London *Ironmonger*, in favor of American-made pipe and the superior condition in which it arrived on the job in Egypt, where he supervised its installation. The author presents the matter to his countrymen "with the sincere hope that in this trade as in others we may scrap obsolete systems in the face of conclusive evidence."

Protectors for pipe threads are not used as a rule, and when specified an extra charge is made by the English manufacturer. Even at that they are not satisfactory, because they usually thread on too far, even beyond the

pipe-end threads, fifteen per cent. requiring the use of dies on the old thread or the cutting of entirely new threads. Not in a single instance was it necessary in any manner to touch the American threads, although three-fourths of the entire line was made up of American pipe.

In reference to the standard threads for two and one-half to six-inch pipe, the British standard of eleven threads to the inch was held to be too fine and eight to the inch much better. A large proportion of the joints made with the fine threads leaked under water test, notwithstanding the free use of red lead, while one could travel for miles along the American pipe without finding one leaking joint, even when no red lead had been used. Sockets with recessed ends received favorable comment. Twice the number of joints, stated the writer, could be made in a day by a given number of men.

In conclusion Mr. Donald said: "This is a strong indictment, but when one hears British sappers and engineers cry with one voice 'give us Yankee pipe,' one feels strongly on the point. Since the export of tubes is prohibited, the greater part of the world is bound to go to America for pipe and when once the United States thread and pipe is adopted the opportunity of regaining the market is remote."

It is indeed gratifying to hear whole-hearted commendation of American products in foreign competition.

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Carelessness in the Power Plant

As the ambulance clanged past the office on its way to the hospital we wondered if it was a case of injury due to carelessness on the part of the victim, or whether it was the expected that accompanies the ordinary hazards of industrial work.

Many workmen are careless, but the accepted belief that most of them are is not true; and where one reads of the hundreds who are injured through carelessness, the thousands who labor through the year without accident are overlooked.

Although most workmen are not careless, most injuries are due to careless workmen. There will always be the man who did not know the gun was loaded, who will work about machinery with his shirt sleeves dangling, and who will rush across the track in front of a train and then stand and watch it pass. This class of person is always being injured or bringing injury to others.

Happily, power-plant accidents are few when compared with the number of men employed. But that an improvement can be made is self-evident. It has been common practice since the adoption of the slogan "Safety First" to post cautionary notices about the steam plant for the guidance of the men. If a workman has a printed notice posted in his department, warning him to be on the safe side in deciding what to do in regard to any particular course of procedure, he is less likely to take a chance.

Power-plant employees are mostly skilled and intelligent and should not require the same safeguarding as would be taken were they illiterate. One thing is certain—if the chief engineer is given to carelessness his example is almost sure to be followed by most of his subordinates, thus producing a condition that is dangerous to all concerned. Any chief engineer who expects to make headway must be watchful of his own actions and see to it that his men are trained to avoid performing their duties under unnecessarily dangerous conditions and impress upon them that caution is the watchword.

It is the duty of the chief engineer to know that all apparatus is in good working order, and each employee should be held accountable for the condition of the apparatus under his care. If the chief insists on keeping in operation apparatus that is out of order the employee is placed in a difficult position, in that he must work with apparatus that is not in condition, or make room for someone who will.

One notice was observed recently in which the operators were instructed to inform the men higher up in case the chief refused to attend to the repairs of any apparatus that might be reported out of order. How long the man who made the report would fill a comfortable position is another question.

It is the practice of some steam railroads to give merit marks to employees who discover defects in train equipment, no matter whether it is on their own or some other train. This has undoubtedly prevented many accidents. Would not the idea work to advantage in the power plant? It certainly would be an incentive for each man to be particularly watchful of his own apparatus as well as of all other in the station.

⁂

We have been hearing from time to time some very strong arguments against the development of our waterfalls for power purposes by the Government. In fact books have been written to show why state-owned central-station enterprises are and always will be a failure. Elsewhere in this issue is a short description of a large Swedish state hydro-electric development on the Alfkarleby Waterfalls. This station is complete and is distributing power to a very extensive system. It cannot be said that this enterprise is an expensive experiment, for it is not the first, but the third, large government-owned hydro-electric plant in Sweden. It will be noted in this article that the cost per kilowatt capacity of this plant is low; comparing quite favorably with the cost for steam plants in this country. It must be acknowledged that our requirements are different from those in Sweden. However, it does not seem possible that these needs are so diametrically opposed to each other that what is an eminent success in one would be a gross failure in the other.

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The article, "Indicator-Diagram Peculiarities," which appeared on page 234 of *Power* for August 15, sent in as an original contribution by Thomas J. Rogers, 805 Coney Island Ave., Brooklyn, N. Y., and used and paid for by us as such, is a paraphrase of Chapter XII of "Indicator Practice and Steam Engine Economy," by Frank F. Hemenway. We present our apologies to the publishers of this work and much regret our inadvertent use, through an imposition, of copyrighted material.

⁂

The owner's pride is the engine room with its bright, shining machinery, but he seldom takes his visitors to the boiler plant and generally does not like to go there himself because it is hot and dirty. It need not be either, and if it is what it should be, he will delight in showing it off.

⁂

Who is next? Erie, Penn., has recently adopted the A. S. M. E. boiler code.

Correspondence

Effect of Shifting Eccentric

On page 67 in the issue of July 11 there is a letter by F. G. Baender on the effects of shifting eccentrics, but there are some statements that need to be more fully explained.

I am asking questions in order to get more explanations. I would like to know to what part of the engine the indicator cord was attached when the diagrams in the second column, Fig. 2, were taken, as the head-end diagram is shorter than the crank-end.

Did this engine have one or two eccentrics? My reason for asking this question is that all the diagrams in Fig. 1 look as if nothing had been changed but the compression. If this is so, and as the letter states the load was not changed, it seems to me that taking off the compression would naturally cause the governor to rise, shortening and not lengthening the cutoff. Some years ago a man called "Noncompression Johnson," of Lynn, contended that taking compression off any steam engine shortened the point of cutoff, provided of course the engine has a constant load; then the area of the diagram would not increase unless the spring in the indicator was changed.

I wish to call Mr. Baender's attention to another statement in his letter regarding the steam pressure being constant at 70 lb. If this is the case, why has the initial pressure changed on diagrams marked *C*, *D* and *E* in Fig. 2? Was the spring changed in the indicator? And also, what caused the high back pressure on diagram *C*, Fig. 2, if everything remained the same as when diagram *A*, Fig. 1, was taken and nothing shifted but the eccentric? I believe some readers would be interested in having explained to them what other changes were made besides shifting the eccentric 9 deg. backward and 9 deg. forward.

Fall River, Mass. M. H. HARRINGTON.

Alternator Excitation and Exciters

I have read with considerable interest the article in your Aug. 1 issue by Gordon Fox on "Alternator Excitation and Exciters." In discussing separate exciters, Mr. Fox says: "These may be driven by their own prime movers or by motors. The efficiency of independently driven units is low because of their small size. Motor-driven units are cheaper and efficient, but are dependent upon the alternating-current system."

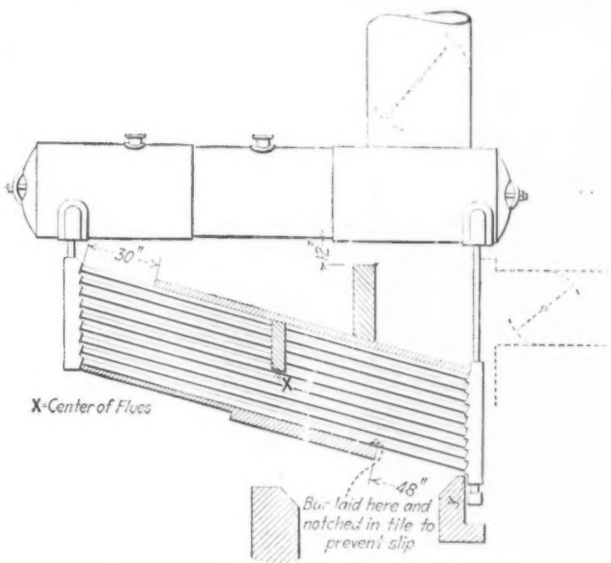
It might be of interest to readers of *Power* to know that there is now available a source of drive for exciters that obviates both of the objections mentioned in the foregoing quotation. This drive is known as duplex drive, because it consists of a motor at one end of the set and a steam turbine at the other. This set is of course independent of the alternating-current system and will, if properly handled, give a higher all-day efficiency than a straight motor-driven exciter. This is possible because at times of peak load on the station the exhaust steam from the turbine can be economically used in the feed-water heater so that the efficiency of the set under these conditions will be considerably higher than can be obtained with a motor drive. This method of operation also relieves the main generators from carrying the exciter load at times when the main generators are already heavily loaded. A description and illustration of one of these duplex-driven sets was published in your July 18, 1916, issue. N. L. SNOW.

Hartford, Conn.

Horizontal and Vertical Baffling

Mr. Viall's article in the June 20 issue of *Power*, on "Horizontal and Vertical Baffling," is about an interesting subject worthy of the most careful consideration. The writer has had considerable experience with the different types of baffling and would like to add something that may be of interest.

The saving derived from a change of baffling generally depends on the local conditions. In localities where coal high in volatile and moisture is being used, cases of rebaffling have been known to increase the boiler and grate



SUCCESSFUL HORIZONTAL BAFFLING

efficiency fully 15 per cent., owing to raising the temperature of the combustion chamber to the ignition point of the gases before they come in contact with the heating surface. In other localities with high-carbon coals, the vertical baffle is a favorite. If more attention were given at the outset to the kind of fuel to be used and the boilers baffled accordingly, it would be a great help to the engineer who has to operate them.

Of the different types of horizontal baffling, I have had better success with the one shown in the accompanying sketch than with any other. It is easy to keep clean, and there is no danger of short-circuits or pockets for dust to collect; also it is the simplest and cheapest to install, and boilers equipped with it have shown remarkable absorption and low stack temperatures.

The lower row of tubes is baffled over the furnace with T tile, and just in front of the bridge-wall the encircling tile begins and is extended back to about 48 in. from the rear header. The object of exposing the flues over the furnace is to reduce the temperature and prevent too rapid distillation of the volatile. As the gases come in contact with the incandescent tile over and back of the bridge-wall, the ignition temperature is reached and combustion takes place before the gases come in contact with the tubes. The section of vertical baffle extending down to the center of the bank of tubes breaks the path of the hot gases and induces uniform distribution.

As only a small portion of the upper wall underneath the drums is removed, the gases must follow the drums instead of lower down, which would be the case if the wall were removed entirely, and more especially if the breeching outlet were horizontal.

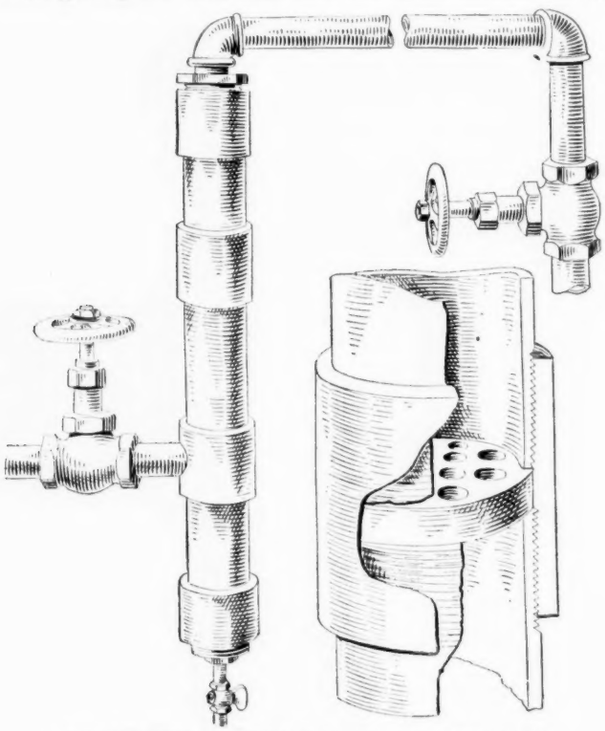
The loss of draft through the boiler with this type of baffling, if the release area and combustion chamber are properly proportioned, is about the same as with the vertical baffling.

W. J. MANHIRE.

Kansas City, Mo.

Easily Constructed Separator

A good deal of trouble was experienced in regulating the speed of a 14x7x14 direct-acting steam pump used for boiler-feed purposes, on account of the condensate cutting away the valve disks and seat of the throttle valve,



SEPARATOR IN STEAM LINE TO FEED PUMP

so we decided to make a separator as shown in the illustration. The result of our effort was somewhat crude, but it has done away almost entirely with the valve trouble. This separator was made almost wholly from old fittings, the baffle being a disk held between the nipple ends and having 12 holes $\frac{3}{16}$ in. in diameter drilled through it. It took two men about two hours to make and put it into service.

J. L. BALL.

Amsterdam, Ohio.

Water-Works and Water-Tube Types of Condensers

Referring to Mr. Quayle's letter in the issue of June 27, which is a reply to my letter in the May 23 issue, I wish to point out in answer to Mr. Quayle that I was not particularly concerned with the engineering in the Kirtland Station, with which, as he states, I was not familiar.

My purpose in writing to *Power* was to point out, using figures on that station as an example, that water-works condensers were not giving high transmission coefficients and correspondingly high vacuum when surface and water temperature were considered, and that this was due to the inherent limitations in design of the steam tube condenser.

Perhaps the real point at issue is the importance placed on very high vacuum by different engineers and also the definition of high vacuum. Some engineers believe that eventually we shall install equipment to give 29 in. in summer with 70 deg. water to 29½ in winter with 40 deg. water, these being their ideas of high vacuum.

It would seem that with the high load-factor conditions prevailing in almost all pumping stations (not, however, in the Kirtland Station, which was temporary, as justly pointed out by Mr. Quayle), every fraction of an inch of vacuum would be extremely valuable in fuel economy. The gain in energy available, which can be realized as additional per cent. output in a suitably designed turbine, is as follows, based on 28½ in. and 200 lb. initial pressure and 150 deg. superheat:

	Per Cent.
28½-in. vacuum	...
29 -in. vacuum	5.2
29¼-in. vacuum	9.1
29½-in. vacuum	13.35

New York, N. Y. PAUL A. BANCEL.

Interruptions Caused by Cable Faults

In most of the modern power equipments the distribution lines are entirely underground in the form of lead-covered cables. These cables are at times subjected to severe strains due to overloads, grounds, shorts, etc., which together with the heat weaken the insulation and dry out the compound. In time, the cable breaks down.

It is not possible that all the interruptions and disturbances caused by faulty cables can be prevented. However, different means can be employed, by which the life can be prolonged, thus eliminating considerable trouble.

Workmen sometimes drive test rods from the street surface to determine the condition of the soil below, without giving duct lines any consideration until the cable or cables have been injured. Very often, to avoid taking up the sidewalk, pipes are driven from dwellings to the street for gas connections, and on one occasion signs were nailed to cables on Brooklyn Bridge. In many of these cases it happened that the live parts were not reached; but if the cable is struck, it will be injured and a breakdown can be expected at any time.

Trouble resulting from just such cases may be guarded against if megger readings are taken once or twice a month. The cables that do not prove satisfactory should be given a high potential test from 50 to 100 per cent. over voltage for about 3 min. If the cable breaks down, a location test can be made, the cable repaired, again tested and put back into service.

Referring to one particular case where a cable proved to be in poor condition, as it happened the street was open due to other trouble and the ducts were left exposed at various places. At one of these openings the cable was found to be swollen to twice its original size, the under side split for a distance of two feet and the insulating material burnt so as to leave the wires exposed. This cable had carried a load of 4,000 kw. at 13,000 volts up to the time the discovery was made. In this case it was excessive heat and not an injury, but the incident illustrates how such interruptions may occur.

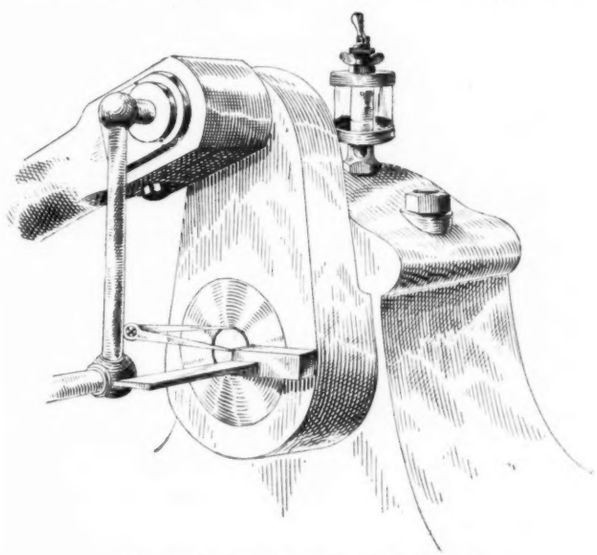
Where lead-covered cables are run in a vertical position, as frequently occurs in station construction, I have found that these sections give considerable trouble, due to the heat, which causes the compound to run down and thus dry out the insulating material. This has been overcome somewhat by placing a small hole in the cover of the cable bell; then instead of filling the bell with a solid compound, it is filled with an insulating compound that is heated and poured in and remains in a more liquid form. By filling the cable bell from time to time, every two or three weeks, the insulation will keep moist.

Cable systems are interconnected in such a manner that voltage cannot be built up on any one cable without interference with other sections. Furthermore, it would not be desirable to take a chance with a good cable for the sake of a faulty one. Therefore, in a station having a great number of cables a separate testing set is employed.

Parlin, N. J. J. W. TRUESDELL.

Adjusting Centrifugal Oilers

Mr. Merriam's device illustrated on page 926, *Power*, June 27, looks like a neat and practical arrangement for centering the oiler ball, but considering the work necessary to make the device, I would as soon use the square as a



SQUARE FOR CENTERING OILER

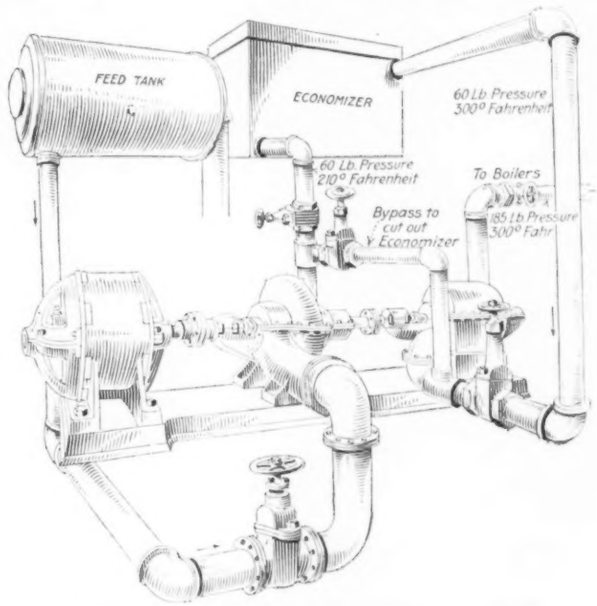
means of centering the oiler. Here is my way of doing it, and I can set and tighten an oiler in about a minute:

I take a pair of dividers and scribe a circle on the end of the shaft around the shaft center, the exact outside diameter of the ball. Then I set the carpenter's square up to this circle and bring the ball to the long blade and make it fast. This method is accurate and rapid.

Ringwood Manor, N. J. A. A. BLANCHARD.

Reduced-Pressure Economizers

George H. Diman's article in the Apr. 25 issue, page 595, and L. M. Hadley's comments in the issue of May 30, page 779, regarding the reduction of pressure on economizers, are very important. Cast iron, which is the only material found suitable for economizers, is not desirable for the high pressures now in use. I think the centrifugal pump offers the best solution and does not complicate the piping very much. For this work the pump would consist of three parts—a steam turbine or electric motor and two centrifugal pumps, all mounted



PIPING FOR CONNECTING PUMPS IN SERIES

on a common bedplate. The piping would be as shown in the illustration. Water at 210 deg. and atmospheric pressure would flow into the suction of the single-stage volute pump, which would be designed to raise the pressure to 60 lb. gage and force it through the economizer. The temperature would be increased to 300 deg. After leaving the economizer the water would enter the multistage turbine pump and be discharged into the feed main at 185 lb. pressure and 300 deg. F. temperature.

The centrifugal pump has an advantage over the reciprocating pump in that the delivery pressure is controlled by the design of the pump, while in the latter case pressure governors would have to be used. I believe that most breaks in economizers are not caused by the regular working pressure, but from over-pressure, shocks and strains produced by improper operation of valves and dampers. JOSEPH R. GILL.

West Somerville, Mass.

Supposed Boilers To Be Empty

A fireman was seriously and probably fatally scalded in an unusual manner in the plant of the Berghoff brewery, Fort Wayne, Ind., on July 9.

It seems that the fireman opened the blowoff valve for the purpose of draining the boiler preparatory to cleaning. In about 20 minutes he disconnected the flange joint between the blowoff valve and the boiler. Seeing no escape of water, he then proceeded to open the lower front handhole. When the head was knocked in, a rush

of hot water enveloped the unfortunate man, scalding him all over, except his head, which was above the boiler opening.

The plausible explanation of the fact that no water escaped when the pipe flanges were separated is that no air entered the boiler above the water line and a partial vacuum was formed inside so that the external air pressure held the water in the boiler until the head was knocked in, when the air pressure equalized, allowing the water to escape. At any rate, as the foregoing conditions might easily exist, it is well to see to it always that there is an opening to admit air above the water line of a boiler and that all the water is out before opening manholes or handholes, thereby avoiding the risk of such an accident as that described. J. LEWIS.

New York City.

Gas-Sampling Pipes

The question of sampling gas for recorders and Orsats was discussed at a recent meeting of the production committee of a gas and electric association. The general preference was to follow the code that specifies that the pipe should extend across the setting with holes, drilled spirally, whose combined area would not be greater than the cross-sectional area of the pipe.

Does the sample so obtained become an average one? When such a sampling pipe is used in calorimetry there is no certainty that the sample of steam is a correct average sample of that flowing through the line at the time.

In any boiler setting, where the damper does not extend the full width, there will be a wide variation in velocity between the center and sides, especially so at the point where the sample must be taken; and in each corner on either side of the damper there will be dead pockets.

With the sampling pipe made as described, the holes will face in all directions and near the center, where the velocity may be 5 to 30 ft. a sec., a Pitot action will be set up. The sweeping action over or under those holes at right angles to the flow will tend to form a suction counter to that of the recorder. If this is true, and a recorder is connected to one end of this sampling pipe, the sample will be composed chiefly of so-called dead gas from one end of the pipe where the Pitot effect is at a minimum, and the sample will not be an average of the gas passing through the boiler. Or, if the recorder pipe is connected to the center of the pipe, the sample will still fail to be an average one.

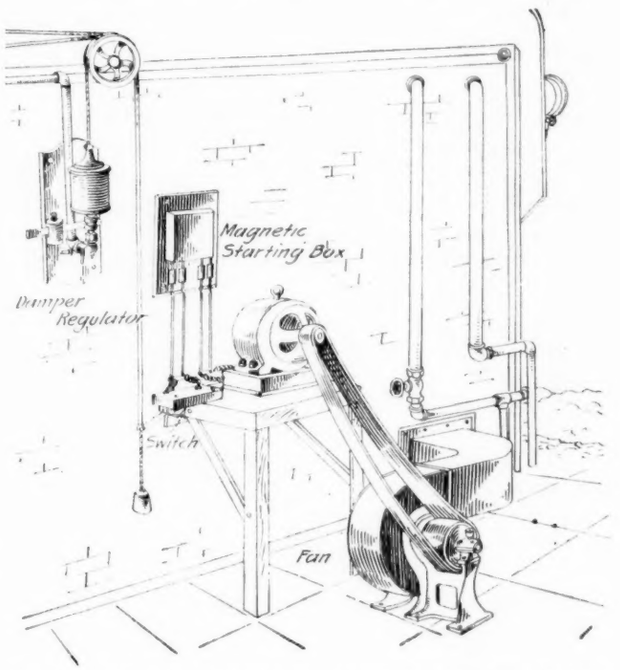
The writer is of the opinion that it would be better to either drill the pipe radially and have it only a little longer than the damper or to use an open end pipe with no other holes, then locate either of these pipes where the composition of the flue gas seems to be most variable under changing conditions of operation. The sample so obtained would not be an average one, although as much so as the former one, but it would be a representative sample of the gas leaving the heating surfaces. Undoubtedly the highest and lowest CO_2 would be found at this point, and by cutting in the Orsat CO would hardly escape detection. But it is believed that a representative sample is more important than a so-called average one. HARRY A. COX.

Middletown, N. Y.

Electrically Operated Draft Fan

The demand for steam made some kind of forced draft necessary, and the outfit shown was installed and gives gratifying results. It happened that the electrical load was not excessive, so a motor-driven fan was installed.

A direct-acting damper regulator, besides closing the stack dampers, breaks the electrical contact and stops the fan. Upon the opening of the dampers by the regulators coming down, contact is made by a chain-controlled switch. We had a magnetic starting box so that the motor might automatically come up to speed. After considerable care in adjusting we got the thing to operate on a two-pound steam variation. EDWARD T. BINNS.



MECHANISM FOR OPERATING DAMPER AND DRAFT FAN

Philadelphia, Penn.

Sodium Hydrate Takes Place of Potassium Hydrate

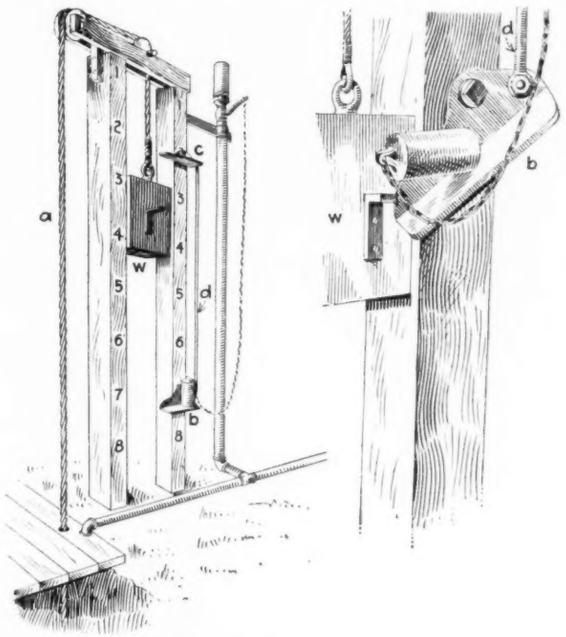
A few months ago we found that potassium hydrate had advanced greatly in price and that little was to be had at any price. Apparently we were "up against it" for the wherewithal to make a caustic solution for our CO_2 recorders and Orsat. As we are familiar with caustic liquor, because of daily contact with it in our processes, it occurred to us that sodium hydrate produced a solution that should apparently give the same results in our recorders as potassium hydrate. We therefore proceeded to experiment.

The only difference that we have found is that the sodium hydrate tends to form crystals and requires more water than potassium hydrate. Also, the sodium solution can be used only about one-half as long. We are therefore using ½ lb. of sodium hydrate crystals in 800 c.c. of water, giving about 1.27 specific gravity, and we renew the solution in the recorders each week (24-hr. service). In checking with potassium we find no difference in the results obtained. H. L. STRONG.

Yarmouthville, Maine.

Sump-Pit Alarm Whistle

The alarm device shown in the illustration was used on a 48x32-in.x10-ft. stroke pump at a sump 300 ft. below the surface. On the float wire *a* we used a beer keg filled with tallow, and a weight *w* was made to balance



COMBINED INDICATOR AND ALARM

the keg. When the water rises to the 7-ft. mark, the arm on the weight upsets the pocket *b* and dumps out a small weight that is attached to the whistle valve by a light chain; when the water falls to the 2-ft. mark, the arm on the weight *w* upsets *c*, which is connected to *b* with a reach rod, and the small weight is again released and the whistle blows. Of course the whistle continues blowing until the engineer closes the valve and hangs the weight on a hook provided for the purpose. This has proved to be a very reliable alarm.

Summit Hill, Penn. F. G. CLARK.

An Easily Made Planimeter

Some time ago it became necessary to figure out the volume of the combustion chamber of a gas engine very accurately. There are a number of ways of doing this,

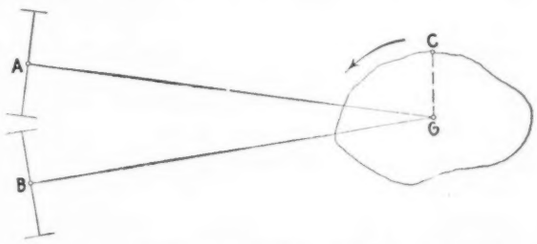


FIG. 1. METHOD OF USING A PLANIMETER

but the quickest and most satisfactory method is to use a planimeter. I was in a hurry for the instrument, but finding that it would take a month to get one, decided to have one made in the toolroom. It was made as shown in 1½ days and was found to be as accurate as one costing about $50, with which it was checked some time later.

The principle on which such a planimeter works is shown in Fig. 1, and it is operated as follows: Place the instrument on the drawing with the tracing needle to the right and as close as possible to the center of gravity of the figure to be measured. In this position say the truck is at *A* and the needle in the truck is pressed to prick the paper at *A* and the needle in the tracer at *G*, the center of the area to be measured. Now move the pointer up and prick the periphery of the figure at *C*, being the point first reached. In tracing, follow the outline in a counter-clockwise direction, as shown by the arrow, and when *C* is again reached, stop and return the pointer to *G*. Depress the needle so as to fix the position of the instrument accurately in the position from which it started, then depress the needle in the truck. This will be marked at *B*. Measure from *A* or *B* to *G* and from *A* to *B* in hundredths of an inch and multiply together. The product will be the area of the figure in square inches.

The distances should be measured each time, because any variation in the setting of the tracing point will

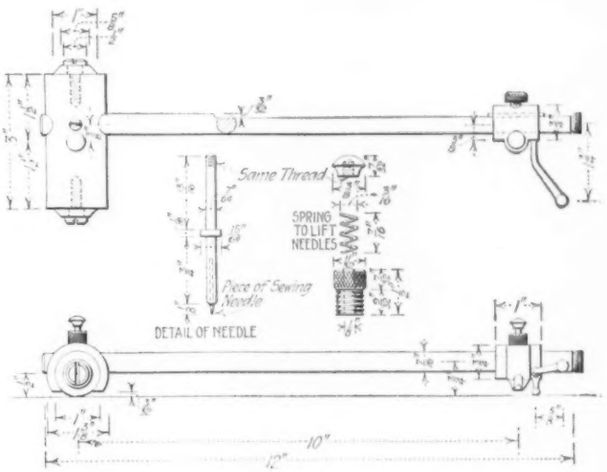


FIG. 2. DETAILS OF CONSTRUCTION

affect the reading. If the area is small, the distance *AG* should be reduced so as to increase *AB* and thus make the reading more accurate. With a little practice in the use of this instrument very accurate results are obtained. Its construction is simple and inexpensive. The illustrations, Figs. 2 and 3, show how it is constructed, and the most important points to observe are the following:

1. The small level wheels of the truck should be mounted together on a mandrel and turned to exactly the same diameter; otherwise the instrument will not be accurate.

2. The beam and the axis of the wheels must be exactly at right angles to insure accurate readings.

3. The adjustable carrier for the tracing needle must be kept from turning; otherwise the tracing needle and that in the truck will not be in a line which forms a right angle with the axis of the wheels. In this construction a flat is provided on one side of the beam and a small half-round piece inserted in the adjustable needle carrier.

4. The needles are held just above the level of the paper so as not to catch. The tracing needle is exposed so that it can easily be seen from all sides as it traces a

figure. A small foot keeps the needle from touching, and a handle is provided to guide the instrument while tracing.

5. The small wheels must have narrow edges, about $^1/_{64}$ in. wide and be equidistant from the center line joining the two needles.

Any good toolmaker ought to be able to make this instrument in two days, and in almost any shop the

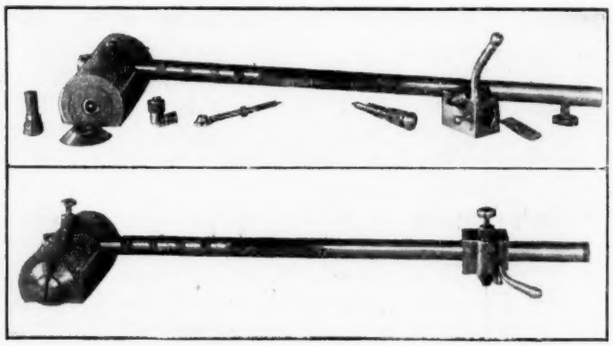


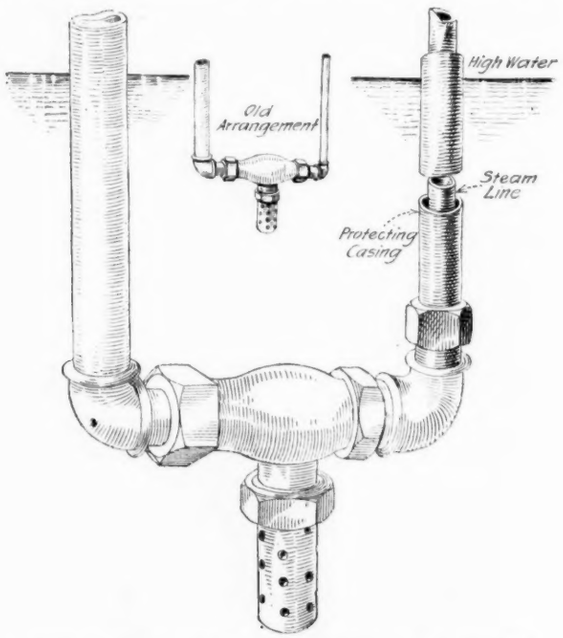
FIG. 3. PLANIMETER COMPLETED AND ASSEMBLED

material should cost practically nothing because scrap can be used. The truck was made from 1½ in. round stock 3 in. long and the beam from a piece of ½-in. steel 12 in. long. CHESTER S. RICKER.

Indianapolis, Ind.

Protecting Submerged Steam Pipe

At a certain mine plant where fuel is cheap, an ejector is used to elevate the water to the main supply tank. During the dry or summer season very little difficulty was ex-



STEAM PIPE PROTECTED FROM COLD WATER

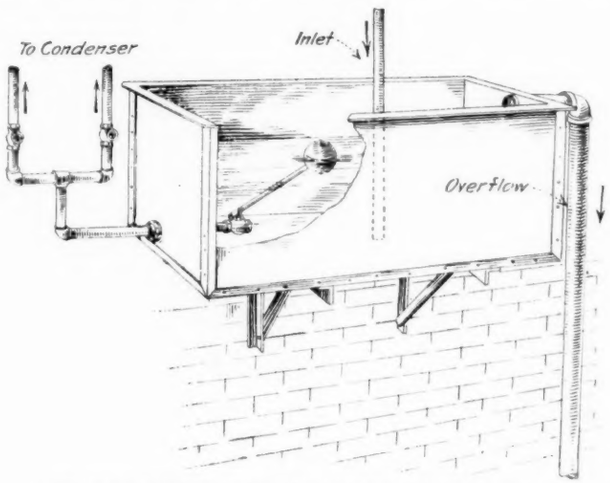
perienced, but in the winter, when heavy rains or thaws come, the water in the creek rises so that the steam line to the ejector is submerged about 3½ ft. With the temperature about zero, the steam pressure was lowered so that the ejector would not throw enough water to supply the demand, and on several occasions temporary shutdowns resulted. There are railroad tracks between the tank and ejector and the piping is underground, so that repiping would be expensive. To overcome the trouble, a casing was placed around the steam pipe by using a larger pipe and making a water-tight joint at the bottom, forming a sleeve so that the water could not come in contact with the steam line, as shown in the illustration. This saves considerable steam, and so far no more shutdowns have occurred on account of no water.

Amsterdam, Ohio. JACK L. BALL.

Saving Waste Water

In the power plant at Douglaston, N. Y., we were using 22,000 gal. of water per day for cooling purposes and makeup feed water. A large part of this was used in the oil-cooling tanks of two 1,500-hp. turbines. It flowed overboard after doing its work in the cooling systems, but this water is now recovered and utilized.

The tank shown has three connections—inlet, outlet and overflow. The waste water mentioned enters at the



WATER RECEIVING AND DISTRIBUTING TANK

inlet. The outlet is connected to and discharges into the two surface condensers, from which it is pumped into the feed-water heater by the hotwell pump. The connection to the condensers is made where the exhaust steam enters, and serves as a condensing jet. Its value is of course relatively small, but will not be wholly negligible at periods when condenser tubes are dirty and condensing water warm.

The tank outlet is controlled by a ¾-in. float valve set to close when the water in the tank becomes low, so that the outlet is always sealed to prevent loss of vacuum. Check valves are provided in case the vacuum is lost and pressure established in the condensers to prevent a reverse flow. Considerable saving in the amount of water used is already apparent. DAVID CRAFT.

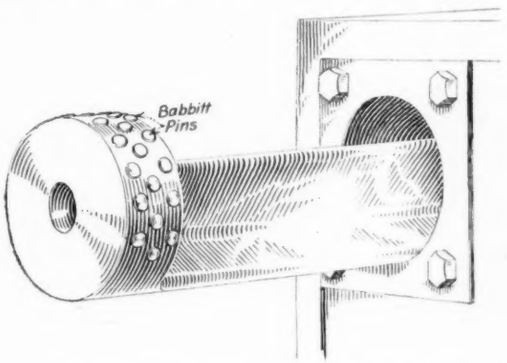
Flushing, N. Y.

The Power Exerted by a Horse when plowing and traveling 1.8 mi. per hr. and pulling about 150 lb. amounts to 0.72 of the so-called mechanical horsepower. Dynamometer tests have shown as high as 200 lb. pull at the rate of 1.8 mi. per hr. This amounts to 0.96 hp. It is therefore evident that when Watt determined the mechanical equivalent of a horsepower he selected a better-than-average horse.

What Distorted the Valves?

I was interested in G. T. Michaels' letter under the head, "What Distorted the Valves?" published in the July 18 issue, page 104, because I had a similar trouble when we started up my present plant. We have a uniflow engine fitted with Corliss valves. Using superheated steam and running noncondensing, these valves expanded with the heat until they stuck in the valve chamber. One valve stem was twisted around 25 deg., and we had to cut a new keyway in the stem. We used a file and scraper to fit the valves and aim to run condensing altogether, in which case the heat is not so intense as to cause the valves to expand enough to stick.

I think if the engineer referred to by Mr. Michaels had used the file and scraper after running about 10 or 12 hours at a time for, say, a week, he would have saved the expense of the machine-shop work and also the new valves. Most erecting engineers use this means to fit Corliss valves when installing new engines, sometimes taking several days to properly fit them to their seats.



VALVE WITH BABBITT PROJECTIONS

If the engineer had taken the valve, after the machinist had turned it down too small, and drilled a few ¾-in. holes on the ends, as shown in the drawing, and filled these with babbitt, allowing it to project about ⅛ in. above the metal, then peened and scraped it down to give the valve about 0.005 in. clearance in the chamber, he would have saved the expense of a new valve and had a better job, because simply renewing the babbitt pins at any future time would give a close-fitting valve again. I did the trick with a discharge valve on a Corliss-valve air compressor where the valve had been fitted too loose in the shop. It always had a disagreeable knock, and on investigating, I found 0.028 clearance in the valve seat. I reduced this to 0.004 in., and the knock has disappeared entirely. I used a ⅝-in. drill for the holes, but ¾- or ⅞-in. would have been better.

Ringwood Manor, N. J. A. A. Blanchard.

Fireman's Goggle Cap

It has been the writer's experience that it is a hard proposition to make a fireman take care of his eyes by wearing dark goggles while working a fire. The general excuse for not doing so is that the goggles cause excessive perspiration around the eyes and clouding of the glass by moisture. Dark spectacles have also been tried, but the metal rims get hot and uncomfortable and both the goggles and spectacles are frequently lost. There is the added objection that the dark-colored glass makes it difficult for the fireman to select from the rack his proper firing tools without raising his glasses. A simple and effective remedy for these difficulties was found in the device illustrated herewith.

An ordinary fireman's or machinist's cap having a stiff visor was used. Holes were cut in the visor and dark goggle lights inserted in such a manner that when working a fire, the fireman has only to duck his head or

GOGGLE CAP FOR FIREMEN

pull down his cap slightly while manipulating. The visor also acts as a shield from the heat and has the advantage that the glass is always ready for use and is just where it is needed.

In small plants, where firemen are their own water-tenders, a cap of this kind is especially desirable. Without some protection the eyes are blinded by the furnace glare, and the water level cannot be readily seen for some moments after cleaning fires, etc. A. W. Conklin.

Appleton, Wis.

Circular-Mil Formula Derived

The derivation of the formula for computing the cross-sectional area of a copper conductor in circular mils for transmitting a specified amperage with a maximum permissible drop in voltage (as appeared in the Aug. 15 issue of *Power*) proved to be very interesting to me.

But why should it be necessary to resort to a special formula where one has recourse to wire tables? It is invariably the case that the one having to deal with such problems has access to a standard electrical handbook or at least he should.

If the amperage and volts drop are given, it only remains to apply Ohm's Law, $I = \frac{E}{R}$, from which $R = \frac{E}{I}$

Now, using the values as given in the article referred to for E_d and I, we have for the value of $R = \frac{5}{80} = 0.0625$ ohm; this value is the resistance of the entire length of the conductor cable, which equals $2D = 2 \times 750 = 1{,}500$ ft.

The resistance per foot of this wire will equal $0.0625 \div 1{,}500 = 0.0000417$; the resistance per 1,000 ft. will be 0.0417 ohm. Consulting the tables, this latter value corresponds quite closely to a 250,000-circ.mil cable.

From the foregoing, R per 1,000 ft. of the conductor in question $= \frac{1{,}000E_d}{IL}$ therefore $L = \frac{E_d}{R \text{ per ft.} \times I}$ and $E_d = R$ per ft. $\times IL$. Substituting the values in these equations for I, L and R per ft., and solving respectively for L and E_d, we have: $L = \frac{5}{0.0000417 \times 80} = 1{,}499$ ft.; and $E_d = 0.0000417 \times 80 \times 1{,}500 = 5.004$. Both of these values are very close to the actual.

The derivation of the circular-mil formula may be arrived at along the following line of reasoning: The resistance of a conductor varies directly as its length and inversely as its cross-sectional area. The resistances of two conductors made from the same kind of material, having equal lengths and at the same temperature, are to each other inversely as their cross-sectional areas. The constant 10.8 is accepted practically as the resistance of one circular-mil foot of annealed commercial copper wire at 75 deg. F. The resistance per circular-mil foot of any wire, when the amperes, the volts drop, its length in feet and circular-mil cross-section are known is equal to $\frac{E_d \times \text{circ.mils}}{IL}$; therefore, $\text{circ.mils} = \frac{10.8IL}{E_d}$

AMOS J. CARR.

Fort McKinley, Maine.

[Although it is to be acknowledged that a handbook is useful and in many cases a convenient and expeditious way of arriving at results, nevertheless we fail to see where Mr. Carr has improved the method of finding the circular-mil cross-sectional area of a conductor. It would seem from his letter that about the same amount of calculating has to be done before he is ready to use his handbook as is required to calculate the size of the conductor directly from the circular-mil formula. Furthermore, it has been our experience that the circular-mil formula is in general more at hand out on the job and more easily carried around than a handbook. Although this article was published for its practical usefulness to our readers, it also had another important purpose; namely, to point out to those not familiar with this subject some of the characteristics of the electric circuits.—Editor.]

Evaporation on Tests with Different Fuels

There was published in *Power* of May 30, 1916, an account by Balda E. A. Borenzi of three evaporation tests on the same boiler, using as fuels coke, anthracite screenings and coke breeze. An analysis of the data presented shows a number of inconsistencies, a few of which cannot be discerned, owing to lack of essential data. Many of them, however, are explained by recalculating the table, using the reported figures.

There follow the data as originally published, together with additions and corrections. To facilitate reference to further comments, the items have been numbered in order.

Item 18 notes a difference of about 5 per cent. of ash and refuse between that reported and that calculated for coke breeze. Some question naturally arises as to the accuracy of the percentage of refuse from coke. While no information is given as to the source of this fuel, it is presumed that it is gas-plant coke obtained from the distillation of a good grade of gas coal containing, when charged to the retort, about 34 per cent. of volatile matter and 8.5 per cent. of ash. As practically all of the volatile matter would be distilled, the probable ash in coke would be $\frac{8.5}{1.00 - 0.34} = 12.9$ per cent.

Good practice on hand-fired grates results in the loss of not over ¼ of 1 per cent. unburned carbon with each per cent. of ash, so that the total ash and refuse which is likely to accumulate is between 14 and 15.5 per cent. of dry coke fired. The percentage of ash and refuse from anthracite screenings is also somewhat low. The difficulty is not so much an error in the amount of ash and refuse weighed as the impossibility of correctly determining the refuse in a test of 8 hr. duration. A grate cannot be put in the same condition after a final cleaning as when the test was begun, and in the tests in question a difference of from 38 to 52 lb. is sufficient to influence the refuse results by 1 per cent.

Item 20 gives the heating value of the fuel. Presumably from the efficiency figures, these heating values are on a basis of fuel as fired. Reducing them to "dry coal" basis from the moisture of item 15 will give the dry-coal heating values of item 21. That for coke is reasonable, that for anthracite screenings is somewhat high and that for coke breeze is quite excessive, being much higher than that for pure carbon according to Kent's curve of heating values for various combustibles.

The reported values of boiler horsepower are evidently to be divided by 8, the duration of the test, to give correct values. The only dimension of the boiler recorded is 33 sq.ft. of grate surface. According to standard proportions of horizontal return-tubular boilers, this would correspond to a heating surface of 1,138.5 sq.ft. and to 99 boiler horsepower.

The items of evaporation per pound of fuel are substantially correct. Efficiency of the boiler cannot be checked as the fuel analysis is not reported. It is, however, calculated from the reported heating value and therefore too high in every instance. The efficiency of boiler and grate is correct except for the anthracite-screenings test. In this case a higher efficiency was reported for the boiler and grate than for the boiler alone, a condition that could never arise. The grate efficiency must always be less than 100 per cent., and the combined boiler and grate efficiency is the product of the individual efficiencies.

In reporting a series of tests of this character, it is always advisable to follow as closely as possible the 1915 Test Code of the American Society of Mechanical Engineers. It is often possible, as in the present instance, to formulate a table much briefer than the full Code, but such items as are given should be calculated following the exact manner of the Code. The details of making the calculations are either set forth in the Code form itself or in the numerous appendices which follow it.

New York City. LEO LEOB.

Inquiries of General Interest

Brick Covering for Hot-Water Boiler—It is proposed to increase the efficiency of a hot-water boiler by incasing it in brickwork. Would it be better to have the brickwork tight against the boiler, or have an air space? L. A. B.

Better insulation will be obtained by having a dead-air space between the boiler and the covering, which should be laid in such a manner as to permit expansion of the boiler without cracking the brickwork. Around the fire-door and places where it is necessary to leave openings in the covering, the air space should be sealed off with asbestos wool packed in place only tight enough to prevent circulation of air currents.

Counter Electromotive Force—The armature resistance of a given direct-current motor is 0.25 ohm and takes a current of 37.5 amp. when operating on a 230-volt circuit. What is the value of the counter electromotive force generated in the armature when operating under the conditions? T. C. A.

The counter electromotive force in the armature of any direct-current motor may be calculated from the formula:

$$e = E - RI$$

where

e = Counter electromotive force in volts;
E = Volts applied to the armature terminals;
R = Armature resistance in ohms;
I = Armature current in amperes.

In this case

$$e = 230 - (0.25 \times 37.5) = 220.625 \text{ volts.}$$

Glass Gage Packing of Gasoline Tank—What kind of packing can be used for the glass gage of a gasoline tank? Different kinds of rubber washers that are satisfactory for packing boiler gages have been used, but all are found to be short-lived and to give out unexpectedly. C. W. M.

Rubber packing rings can be used provided they are protected from the solvent action of the gasoline. Give all sides of the rings a coating of shellac varnish, allowing it to dry and harden before the washers are appled. To prevent the varnish from becoming cracked, use smooth molded rubber packing rings of suitable size to go over the glass snugly and to fit into the stuffing-boxes without forcing.

Relative Cost of Wood or Coal as Boiler Fuel—What is the relative cost as boiler fuel of yellow-pine wood containng 25 per cent. moisture and costing $3 per cord as compared with the average quality of bituminous coal at $4.25 per ton of 2,000 lb.? W. F.

A pound of average bituminous coal is equal in evaporative power to about 2¼ lb. of wood containing 25 per cent. moisture. A cord of yellow-pine wood costing $3 and containing 25 per cent. moisture would weigh about 3,125 lb. and would be equivalent to $3{,}125 \div 2\frac{1}{4} = 1{,}339.3$ lb. of bituminous coal at a cost of $(\$3 \times 2{,}000) \div 1{,}339.3$, or about $4.48 per ton. Hence at the prices quoted, and with the same boiler efficiency, coal as fuel would cost about 5 per cent. less than wood.

Larger Safety Valves on Low-Pressure Boilers—For the same area of grate, why are larger safety valves required for boilers carrying lower pressures than for those carrying higher pressures of steam? W. T.

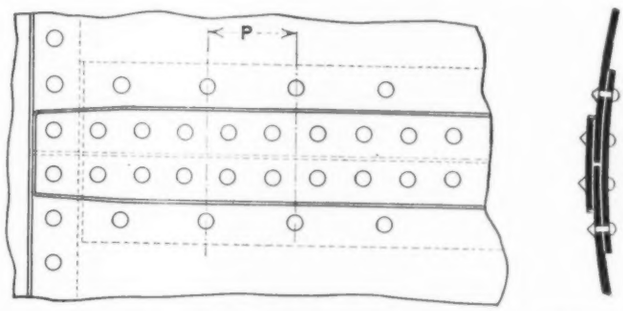
For the same area of grate and same rate of combustion of the fuel per square foot of grate there would be a larger volume of steam generated per second at a lower than at a higher pressure; and besides, the steam at lower pressure, when liberated by the safety valve, would be discharged through the valve at lower velocity. Hence, assuming in either case that the safety valve is large enough to relieve the boiler of steam as fast as it is generated, a larger area of safety valve is required for the boiler that is to be relieved of steam at the lower pressure.

Compound Motor for Driving Fan—Can a compound motor be used to drive an exhaust fan? A. D. L.

A compound motor can be used for this service, but the nature of the load is such that it does not warrant the additional expense. Therefore direct-current motors that are used to drive fans are either series or shunt machines. The series machine is confined to small sizes. In many cases it is required that the fan run at different speeds at different times. If series motors are used, the speed is varied by a resistance in the armature circuit. This method is uneconomical. The better scheme is to use a shunt motor with field control. But the latter would not work very satisfactorily with a compound motor, for when the shunt field is weakened, the current in the series field will, to a large extent, offset the effect of the shunt field, and the speed variation would be only a very small percentage of that in a shunt machine with the same field-current variation. Whenever a compound motor is used on variable-speed drives, the series-field winding must be cut out after the machine has come up to speed.

Butt- and Double-Strap Joint, Double Riveted—What would be the efficiency of a butt- and double-strap joint, double riveted, with the tensile strength of plate 55,000 lb. per sq.in. of section; thickness of plate, $\frac{7}{16} = 0.4375$ in.; thickness of butt straps, $\frac{3}{8} = 0.375$ in.; pitch of rivets of the outer row, 5 in.; diameter of rivet holes, $1\frac{1}{16} = 0.9375$ in., and cross-section of rivets 0.6903 sq.in.; assuming the shearing strength of rivets, 44,000 lb. per sq.in. of cross-section in single shear and 88,000 lb. in double shear; and the crushing strength of the plates and rivets 95,000 lb. per sq.in.? W. T. L.

The efficiency of a joint is the ratio of its strength per repeating section of length to the strength of an equal length



BUTT- AND DOUBLE-STRAP JOINT, DOUBLE RIVETED

of solid plate. Taking the length as P in the sketch, equal to the pitch of rivets in the outer rows, for a unit of pitch the strength of the solid plate would be,

(A) $5 \times 0.4375 \times 55{,}000 = 120{,}313$ lb.

The resistance of the joint per unit of pitch for the different methods of failure would be: The strength of plate between rivet holes in the outer row =

(B) $(5 - 0.9375)\ 0.4375 \times 55{,}000 = 97{,}754$ lb.;

the shearing strength of two rivets in double shear, plus the shearing strength of one rivet in single shear =

(C) $(2 \times 88{,}000 \times 0.6903) + (1 \times 44{,}000 \times 0.693) = 151{,}866$ lb.;

the strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row =

(D) $[(5 - (2 \times 0.9375))\ 0.4375 \times 55{,}000] + (1 \times 44{,}000 \times 0.6903) = 105{,}568$ lb.;

the strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row =

(E) $[(5 - 2(0.9375))\ 0.4375 \times 55{,}000] + (1 \times 0.9375 \times 0.375 \times 95{,}000) = 108{,}594$ lb.;

the crushing strength of plate in front of two rivets, plus the crushing strength of butt strap in front of one rivet =

(F) $(2 \times 0.9375 \times 0.4375 \times 95{,}000) + (0.9375 \times 0.375 \times 95{,}000) = 111{,}328$ lb.;

the crushing strength of plate in front of two rivets, plus the shearing strength of one rivet in single shear =

(G) $(2 \times 0.9375 \times 0.4375 \times 95{,}000) + (1 \times 0.6903 \times 44{,}000) = 108{,}303$ lb.

As the strength of the joint per unit of pitch would depend on (B), the efficiency of the joint would be $\frac{(B)}{(A)} = \frac{97{,}754}{120{,}313}$ or 81.2 per cent. of the strength of the solid plate.

Fractional Valves*

By James A. Donnelly

Modern types of fractional valves are used under diversified conditions, but the tendency of the best and most conservative practice of this country, at the present time, seems to be toward the larger sizes favored in America rather than the smaller sizes of European practice. It was thought therefore that in this investigation of the subject the work of the committee should be directed toward the testing of fractional valves and the determination of the necessary orifices through them, where they were designed to be used under the conditions fixed by the standards that have been suggested to the society, as representing the best of present practice for low-pressure plants. These may be briefly stated as follows:

That the valve is to be adapted for use on and rated for standard cast-iron direct radiation, having a nominal condensing capacity of 0.25 lb. of steam per square foot per hour; that the steam and return mains are of such size that the drop in pressure is not greater than 1 oz. in 100 ft. in straight pipe; that the standard sizes of steam and return connections for two-pipe vapor and vacuum systems are to be used, which are substantially as follows:

	Supply, Square Feet of Radiation		Return, Square Feet of Radiation	
Size, In.	Gravity and Vacuum Steam Connection	Gravity and Vacuum Valve	Gravity Return	Vacuum Return
½	..	20	40	80
¾	20	40	100	200
1	40	80	200	400
1¼	80	160	...	...

Fractional valves are in general use in two broad classes of air return systems: First, gravity systems, which include those in which the water is returned by gravity to the boiler —tank trap, return trap, receiver or other device; and second, vacuum return-line systems, in which a vacuum pump is used on the return line in order to establish and maintain the difference in pressure necessary for circulation by lowering the pressure in the return line.

The gravity systems may be divided into three classes along the lines of the devices used on the outlet of the radiator: The first class is that which uses nothing more than a union elbow, a slight water seal or a check valve of unrestricted opening; the second class is that which uses a check

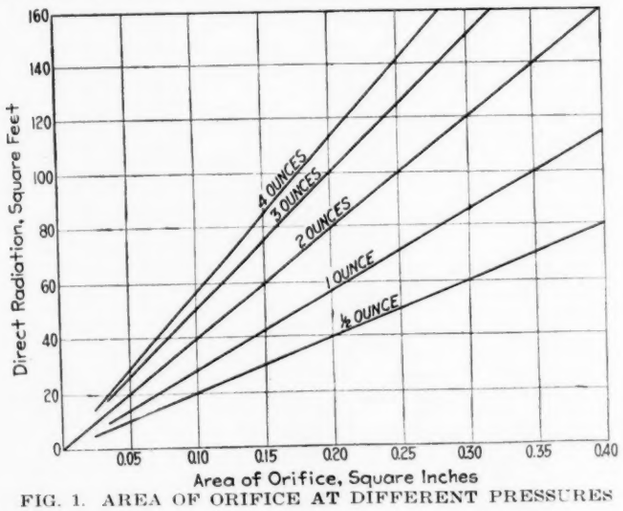


FIG. 1. AREA OF ORIFICE AT DIFFERENT PRESSURES

valve having a seat opening restricted in size or by the weight of the valve disk, or both; the third class is that which uses a float valve thermostatic or vaporizing fluid device on the outlet.

The first class has substantially no restriction to the flow through the outlet device on the radiator; the second class modifies or reduces the flow to a greater or less extent, while the third class permits the escape of air and water from the radiator and prevents the flow of any steam. The function of the fractional valve is therefore somewhat different in each class.

In the first class the maximum opening through the valve is limited to such a size that, at the pressure used, it will pass exactly the proper amount of steam for heating the radiator when the room is at 70 deg. This valve, therefore, attempts to take the place of the outlet valve or to combine the functions of both the outlet and the inlet valves in one valve.

Fractional valves in the two remaining classes are usually made with a maximum opening, which is of sufficient size, at the pressure used, to heat the radiators in a reasonable time, and depend upon the outlet valves to prevent the passage of steam or reduce the flow to a proper amount.

The vacuum return-line systems may be divided into two classes: First, simplex systems, or those which use but one device, and that at the outlet of the radiator, for controlling the circulation; and second, compound systems, which use a combination of two devices for controlling the circulation, one at the outlet of the radiator and the other in the branch return. In the simplex systems the full vacuum produced by the vacuum pump, less the unavoidable friction, extends to the return devices on the outlet of the radiator, and therefore, as soon as the heating effect of the radiator is reduced below the maximum, by the action of the fractional valve, the outlet valve tends to cool; and if of thermostatic or vaporizing fluid design, it opens, reducing the pressure in the radiator to substantially that in the return pipe. If a float valve is used at the outlet, it will not open as a thermostatic valve does, and therefore the pressure in the radiator will be reduced only by the continued throttling action of the inlet valve, until equal to that in the return piping. This, by reason of the increased difference in pressure, renders it necessary that the fractional valve for these systems shall have a much smaller area of opening through the seat to control the flow of steam.

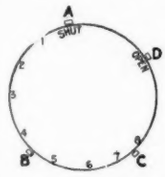


FIG. 2. PROPOSED DIAL ARANGEMENT

In the compound system the full vacuum maintained by the pump is not allowed to extend to the outlet device on the radiator, but is reduced to that necessary for circulation in each group. Fractional valves for these systems will therefore be working under substantially the same conditions as those found in the second and third classes of the gravity systems.

The necessary orifice through the seat of the fractional valves will of course be governed by the drop in pressure chosen as a standard from the steam connection, through the valve, to the radiator. Fractional valves vary in their individual design so much at the present time that it was thought advisable to prepare the accompanying chart showing the areas of orifices necessary, with differences in pressure from ½ to 4 oz.

If the size of pipe supplying the valve in which the orifice is located is sufficiently large so that the friction of flow through it does not materially affect the flow through the orifice, the area of orifice for varying amounts of radiation will vary in direct proportion to the amount of radiation. As the difference in pressure for which the valve is designed varies, the area of the orifice will vary in inverse proportion to the square root of the difference in pressure.

In order that a fractional valve may have a sufficiently large opening to heat a radiator within a reasonable time, the maximum opening should be double that required for the normal heating of the largest radiator for which the valve is rated. If this is the case, the average radiator for which the valve is designed will be completely heated in from 10 to 15 min. after steam is turned on. This, in view of the comparative performance of ordinary direct radiators, is thought to be as rapid as necessary. If a 2-oz. drop from the piping to the radiator is assumed, the maximum orifice for each size of fractional valve for the surface for which it is rated is as follows:

Size, In.	Radiation, Sq.Ft.	Normal Heating — Area of Opening, Sq.In.	Initial Heating — Area of Opening, Sq.In.
½	0 to 20	0.0 to 0.05	0.1
¾	21 to 40	0.05 to 0.1	0.2
1	41 to 80	0.1 to 0.2	0.4
1¼	81 to 160	0.2 to 0.4	0.8

The dial might therefore be arranged as shown in Fig. 2. At the point A the valve would be shut; at B it would be open sufficiently for the normal heating of the smallest radiator for which the valve is rated; at C for the normal heating of the largest radiator; and between the points C and D for the quick heating of a radiator. Between the points A and B it would fractionally control the smaller radiator, and between the points A and C the larger radiator.

*Abstract of paper presented at the semiannual July meeting of the American Society of Heating and Ventilating Engineers.

Edison Rate-Case Rehearing

A rehearing of the entire question of rates that may be charged for electric current within the City of New York has been asked for by the mayor.

The decision of the commission in the Edison case, which also affects the United Electric Light and Power Co.'s service, was made in March, 1915, and it directed that from May 1, 1915, for a period of three years the maximum price to be charged by the company for electric service in the city, exclusive of the installation and renewal of lamps, should be 8c. a kilowatt-hour. This action was taken after forty-six hearings, covering a period of more than a year.

"In respect to the New York Edison rate case," said Commissioner Whitney, "there have been from time to time criticisms of the order and the commission has at various times considered reopening the proceeding both as to the three-year limit and the amount of the rate. As it would consume considerable time to get the data ready, including the valuation of the property, it is thought that the commission should take the matter up so as to be ready for a determination either before or at the end of the three years.

"In respect to the valuation it is to be noted that, although the original case consumed several years, no valuation was made of the property of the company by the commission, a step that would seem to be necessary in any rate case."

The mayor asks for a change in the rate time limit in view of the fact that unless the order is changed it will mean that the consideration of a proper rate will probably last a year or two more, and this would have the effect of continuing the present rate in force for four or five years and probably longer.

The first hearings into electric-current rates were before Commissioner Maltbie and lasted from Oct. 3, 1911, to Dec. 9, 1912. Hearings were resumed in 1914; and in October of that year and early in March, 1915, Commissioner Maltbie presented an opinion recommending a charge of 6½c. a kilowatt-hour for lighting and general use and a maximum rate for power of 6c. a kilowatt-hour. Commissioners McCall and Williams filed opinions in favor of the maximum charge of 8c. a kilowatt-hour, which rate was finally adopted.

Erie, Penn., Has Boiler Inspection and Engineer's License Law

Two ordinances recently passed by the City of Erie, Penn., make it compulsory that boilers hereafter used in the city shall conform to the rules of the American Society of Mechanical Engineers, such rules being known as the Boiler Code. Boilers on road vehicles and those in private residences for not more than two families are exempt, as are boilers under Federal jurisdiction.

The inspector is authorized to examine each boiler at least once a year unless it is inspected by a casualty company. The hydrostatic test calls for a pressure 50 per cent. greater than the working pressure. At least two methods of feeding the boilers are required.

The inspector is required to give ten days' notice before making an inspection, and should the owner of the boiler desire inspection, he is required to notify the boiler inspector ten days previous to the date of inspection.

For each boiler annually inspected by the city inspector, $5 shall be paid to the city treasurer. Boilers that are inspected by casualty companies shall be paid for at the rate of $1 each, to be paid by the city treasurer. For violation of the rules of the ordinance, a fine of not less than $25 nor more than $100 or, on default of payment, commitment to the Erie County jail for a period not exceeding thirty days is provided. This ordinance is No. 4,124.

Ordinance No. 4,125 provides for the licensing of engineers and firemen. To run a boiler or an engine a man must be 21 years of age, and must be certified after examination as to his competency and safety. A fee of $3 is charged for the license, which shall be renewed annually without examination and upon a payment of $1, provided that it is presented within ten days after its expiration. Licenses are graded into two classes, one of which entitles the holder to have charge of or operate stationary steam boilers and steam engines only; the other entitles the licensee to have charge of or to operate portable steam boilers and steam engines only. No person is eligible to an examination for a license unless he furnishes proof that he has been employed about a steam boiler or steam engine for a period of not less than two years prior to the date of application. Engineers are required to keep an accurate record of repairs, washings or other work of like kind that may be done to the boilers. When an engineer vacates or takes a position, he must notify the boiler inspector.

Any person violating the provisions of the ordinance is liable to a fine of not less than $25 nor more than $100, or, in default of payment, may be committed to the Erie County jail for a period not exceeding thirty days.

ENGINEERING AFFAIRS

The Association of Edison Illuminating Companies will hold its annual convention at Hot Springs, Va., Sept. 4-7, with headquarters at The Homestead.

The National Association of Cotton Manufacturers will hold its semi-annual meeting in New London, Conn., Sept. 14-16, with headquarters at The Griswold. An attractive program has been arranged and a large attendance expected.

The Northwest Electric Light and Power Association will hold its ninth annual convention at Seattle, Wash., Sept. 6-9, with headquarters at the New Washington Hotel. The entertainment features have been arranged jointly by the entertainment committees of the Northwest Electric Light and Power Association and the American Institute of Electrical Engineers.

The Association of Iron and Steel Electrical Engineers will hold its tenth annual convention in Chicago, Ill., Sept. 18-22, with headquarters at the La Salle Hotel. Arrangements have been made to visit the power stations of the Commonwealth Edison Co. and several large steel plants. There will be very interesting papers presented, discussions and other highly attractive features.

MISCELLANEOUS NEWS

A Locomotive Boiler Exploded near South Bend, Ind., killing the engineer and fireman. It is reported that the front end of the boiler gave way.

The Bursting of a 20-Ft. Flywheel on Aug. 23 at the plant of the St. Louis Portland Cement Co., at St. Louis, Mo., wrecked the engine room and caused $160,000 damage to the plant. The engineer was killed and five other workmen, who were in the engine room at the time of the accident, were injured.

The Western Carolina Power Co. is to begin immediately its Bridgewater development, 10 mi. above Morgantown, on the Catawba River. The plant, when completed, will have a capacity of 26,000 hp. Plans and specifications have been prepared, and bids were opened in Charlotte, N. C., on July 12. This company is a subsidiary of the Southern Power Co.

The Northern States Power Co. has announced that it will spend $500,000 for bringing power to St. Paul and Minneapolis, sufficient to care for a population of 4,000,000 persons. A series of high-tension cables will be carried from Chippewa Falls, Wis., where there is one of the most modern power plants in the country. Other lines will be run from Taylors Falls, Coon Creek, Rapidan and Cannon Falls.

Two Men Were Scalded to such an extent as to cause their deaths while doing repair work inside of a boiler adjoining others under pressure, at the plant of the Malleable Casting Co., Sharon, Penn., Aug. 10. It is not clear from present reports just how the steam got into the boiler in which they were engaged—whether through the steam line or the blowoff pipe. Each victim leaves a family of three small children.

Geared Turbines for Destroyers—It has recently been announced that the Navy Department intends to re-engine a number of ships in the service that are now equipped with direct-connected turbines. The first two to be so reconstructed will be the destroyers "Henley" and "Mayrant." These are to be equipped with Westinghouse geared-turbine units. The machinery to be supplied for the "Henley" will consist of two complete expansion-geared-turbine units of the impulse-reaction type with Kingsbury thrust bearings, and two geared cruising units. The installation is to be made in the same engine-room space and to connect with the existing propeller shafting and drive the propellers at the same speed as formerly. Reduction gears will reduce the

turbine speed of 3,000 r.p.m. down to 640 r.p.m. for the propeller shaft. The new machinery for the "Mayrant" will be essentially the same as that for the "Henley." The main turbines, however, will each have a capacity of 7,000 hp. at the propeller shaft, which will run at a speed of 629 r.p.m. The speed of the turbines will be 3,000 r.p.m.

Fatal Explosion at Jackson, Tenn.—A boiler explosion involving three separate steam units, in the Harlan-Morris stave factory at Jackson, Tenn., caused the death of eight or more employees and the injury of probably twice that number, on the morning of Aug. 21. It is probable that a greater loss of life would have resulted if the explosion had occurred at a later hour, with the entire force of about 75 persons present. No report of the findings of the coroner's jury as to the cause and responsibility for the accident is yet available, but will be given in a later issue.

Recent Legal Decisions

Concrete Mixer as "Establishment"—A self-propelling concrete mixer is an "establishment" within the meaning of the Iowa statute which requires those in charge of a manufacturing or other establishment to safeguard cogs, gearing, etc., on all mechanical contrivances. (Iowa Supreme Court, Plew vs. James Horrabin & Co., 157 "Northwestern Reporter," 453.)

Taxation of Power Companies—A revenue or license tax imposed against an electric power company by a city is not invalidated because it will reduce the company's profits under existing contracts to furnish electricity, since all contracts are subject to proper exercise of the public power of taxation. (Oregon Supreme Court, City of Portland vs. Portland Railway, Light and Power Co., 156 "Pacific Reporter," 1058.)

Effect of Indiana Factory Act—The Indiana statute which requires the owner of mechanical establishments to equip machinery with belt shifters when required by the state factory inspector, and which imposes a duty upon employers of safeguarding cogs, etc., does not make the latter duty dependent upon an order issued by the inspector. So the owner of a pumping plant is liable for injury resulting from negligent failure to safeguard cogs, while the injured employee in the course of his duties was attempting to unscrew the top of an oil cup near the cogs. (Indiana Appellate Court, Indiana Quarries Co. vs. Smallwood, 112 "Northeastern Reporter," 549.)

Proof as to Negligence in Boiler Explosion—In an action by a pumping-plant employee to recover damages for injuries sustained in the explosion of a boiler, the vital issue being whether the tubes had been negligently maintained in a defective condition, defendant was entitled to show a general custom as to the length of time boilers were used without cleaning, to meet testimony in favor of plaintiff tending to show that there was no regular time for cleaning them, that they ran anywhere from two to three months without cleaning, and that the plaintiff, although he had never known of another explosion in defendant's plant, had seen the boiler tubes so bad that they could not hold steam. (District of Columbia Court of Appeals, District of Columbia vs. Flagg, 42 "Appeal Cases," 73.)

Accidents Within "Course of Employment"—When an employee in charge of a boiler is injured in splitting wood as fuel for the boiler or in handling cans used in removing ashes, the accident is properly regarded as having arisen in the course of his employment so as to be subject to award under the Workmen's Compensation Act, according to ruling of the New York State Industrial Commission. (Kiernan vs. Schermerhorn.) The commission has also sustained an award for fatal injuries suffered by a boiler fireman and found to have resulted from his becoming unconscious on inhaling a puff of gas and falling to the floor, where he struck his head, although there was some evidence tending to show that the accident may have been caused by a diseased condition in his head. (Moss vs. Ames Iron Works, Claim No. 62,536.)

Termination of Electric Service Contract—Where a company which contracted for electric service to be furnished by a power company, on condition that the service might be discontinued on notice on nonpayment for service three months in arrears, was succeeded by another company, notice served on the president and general manager of the succeeding company was not invalidated because it was directed to the original company, especially since such officer had also been president and general manager of the first corporation. A power company's acceptance of notes of a third party for an amount due from a consumer does not release the consumer from liability, on nonpayment of the notes, in the absence of an agreement that the notes shall be accepted as payment by the consumer. (United States Circuit Court of Appeals, Eighth Circuit, Maxwell vs. Holmesville Mill and Power Co., 231 "Federal Reporter," 684.)

Duty to Safeguard Steam Pipes—In affirming judgment against a dam-construction company for injury to an employee, due to breaking of a steam pipe through lack of proper support where it ran along the ground to a connection with an upright boiler used in the work, or through chemical action of ashes which surrounded the pipe, the Massachusetts Supreme Judicial Court recently said in the case of Joyce vs. Power Construction Co., 113 "Northeastern Reporter," 275:

> While it may be properly said that the pipe lines, because of their transitory nature, are of the class of instrumentalities and appliances that may be left to the construction, supervision, care or oversight of servants or agents, it cannot be affirmed that a boiler and its connections are not permanent appliances when situated as this boiler was. . . . Nor can it be said that the master owed no duty to its servants to maintain the boiler and its connections in a reasonably safe condition or to warn those using them of dangers and perils attending their use. . . . Assuming that the break in the pipe was due in part to failure of coservants to perform a duty to provide continuous support to the pipe outside the shack, and in part to the neglect of the defendant to properly protect the pipe within the shack from corrosion, the plaintiff established a cause of action.

The court also holds that even if plaintiff knew that chemical action might impair the pipe, he had a right to assume that his employer had equal knowledge and would safeguard the pipe against such action.

BUSINESS ITEMS

The Burt Manufacturing Co., of Akron, Ohio, has found it necessary to enlarge its manufacturing facilities and is just completing two large two-story additions to its factory. In the past this company has devoted its efforts exclusively to the manufacture and sale of oil filters, exhaust heads and ventilators, but in the future it proposes to branch out into a general line of sheet-metal work.

N. A. S. E. Invitation—Undoubtedly those who read the advertisement of the Lunkenheimer Co. which appeared on page 4 of the Aug. 15 issue were at a loss to understand the invitation extended in this announcement to delegates and visitors attending the Iowa State N. A. S. E. convention at Waterloo to visit its booth, inasmuch as the convention had taken place last May. In explanation, "Power" was instructed to repeat in the Aug. 15 issue an advertisement which appeared in an issue just previous to the time of the convention and which contained the invitation mentioned. Through error, this invitation was left in the advertisement appearing in the later issue.

The Crocker-Wheeler Co., of Ampere, N. J., announces the removal of its San Francisco office from the Crossley Building to the ground floor of 87 New Montgomery St., with W. K. Brown as district manager. A large assortment of motors, generators and transformers will be carried in stock for the convenience of buyers of electrical equipment on the Pacific Coast.

CATALOGS RECEIVED

Improved Wing Turbine Blower. L. J. Wing Manufacturing Co., 352-392 West 13th St., New York. Bulletin No. 37. Illustrated.

Oil Filters. William W. Nugent & Co., Chicago, Ill. Bulletin. Pp. 16, 6x9 in. This illustrates and describes improved oil filter with automatic water separator.

Air Compressors. Chicago Pneumatic Tool Co., Chicago, Ill. Bulletin 34-N. Pp. 20, 6x9 in. Single steam and belt-driven compressors are described and illustrated in this bulletin.

Electric Hoists. Sprague Electric Works, 527 W. 34th St., New York. Bulletin No. 48,906. Pp. 32, 8x10½ in. This illustrates and describes Type S-1, one-half-ton and one-ton hoists.

Heraeus Quartz Resistance Thermometers. The Hanovia Chemical and Manufacturing Co., Chestnut St. and N. J. Railroad Ave., Newark, N. J. Bulletin No. 15. Pp. 8, 8½x10½ in. Illustrated. Describes this company's line of resistance thermometers for measuring on a switchboard temperatures from —330 to +1,300 deg. F.

Link-Belt Sprocket Wheels, Traction Wheels, Gears, Buckets, Etc. Link-Belt Co., Chicago, Ill. Book No. 275. Pp. 112, 6x9 in. This contains revised list prices effective July 15, 1916.